15 Appendix B Palaeontological Heritage Report Proposed Mainstream San Kraal Wind Energy Facility near Noupoort, Northern and Eastern Cape

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EXECUTIVE SUMMARY

San Kraal Wind Farm (Pty) Ltd are proposing to construct the San Kraal Wind Energy Facility (WEF) with up to 75 wind turbines and an approximately 25 km long grid connection to the Umsobomvu substation. The project area spans the border between the Noupoort District, Northern Cape and Middelburg District, Eastern Cape. Most of the San Kraal WEF footprint will be situated in dissected rocky plateau areas underlain by continental sediments of the Katberg Formation (Upper Beaufort Group / Tarkastad Subgroup, Karoo Supergroup) of earliest Triassic age. Latest Permian sediments of the underlying Balfour Formation crop out along the foot of the Katberg escarpment but are generally mantled by a thick apron of colluvium (sandy and gravelly scree, hillwash) and alluvium. Elsewhere in the Main Karoo Basin these sediments have yielded locally abundant vertebrate fossils, large vertebrate burrows, a small range of invertebrate burrows but only rare plant remains. The uppermost Balfour and Katberg Formations preserve an important record of biological and palaeoenvironmental events on land during the catastrophic Permo-Triassic extinction of 252 Ma (million years ago) and subsequent biotic recovery. Several vertebrate fossil localities in the Noupoort area are noted in the scientific literature but only a few fossil remains were recorded during a four-day field assessment of the San Kraal WEF and associated powerline. These include fragmentary bones and teeth within calcrete breccias as well as several large vertebrate burrows, one with associated disarticulated bones. The paucity of recorded fossil sites here is probably due to (1) the very low exposure levels seen here of overbank mudrocks where most fossils are preserved, and (2) the predominance of amalgamated channel sandstone facies in the upper part of the Katberg Formation building the plateau areas. Scientifically-important fossil remains in the subsurface may well be compromised by the proposed WEF development during the construction phase, notably due to voluminous bedrock excavations for wind turbine footings.

No palaeontological No-Go areas or highly-sensitive fossil sites have been identified within the main WEF development footprint on the Katberg sandstone plateau (Fig. 33). All fossil finds here are assigned a low field rating (Local Resource IIIC) and do not warrant mitigation. A 50 m-radius protective buffer zone is proposed for several vertebrate burrow sites along a stream bed on farm Winterhoek 118 (Field rating Local Resource IIIB). They lie close to the alignment of the Alternative 1 132 kV powerline route which, if chosen, should be moved slightly to the southeast in this sector to lie outside the proposed buffer zone (See Figs. 35 and 36 herein). Alternative 1 is the least-preferred route option from a heritage viewpoint for this reason, with no preference for either one of the other two route options under consideration.

Due to the low extent, inferred moderate severity and permanent duration of potential palaeontological impacts, the impact significance of the proposed WEF is assessed as *medium (negative)* before mitigation. Confidence levels in this assessment are *medium*, given (1) the extensive palaeontological literature on the Karoo bedrocks concerned weighed against (2) very low levels of bedrock exposure within the study area and (3) the unpredictable distribution of well-preserved fossils.

Given (1) the significant potential for scientifically-valuable fossils being disturbed, damaged or destroyed during the construction phase of the WEF as well as (2) the high level of uncertainty regarding fossil distribution in the subsurface, a precautionary approach to palaeontological mitigation is considered appropriate here. Following discussions with SAHRA (Dr Ragna Redelstorff, Oct. 2017), it is therefore proposed that initially a representative sample (*c*. 10%) of excavations for wind turbine footings be monitored by a professional palaeontologist during the early construction phase. The monitoring protocol should be developed by the palaeontologist appointed in consultation with the developer and SAHRA so as to maximise the palaeontological outcome without interfering unduly with the construction program. On completion of this initial phase of monitoring, a Phase 2 palaeontological report, with recommendations for further specialist monitoring or mitigation (if any), should be submitted by the palaeontologist to SAHRA for comment. This stepwise monitoring approach is recommended because it may well prove impracticable to recognise, record and sample useful fossil material from turbine excavations due to factors such as excessive fragmentation of the bedrock and fossils, obscuring of freshly-excavated bedrock by soil or dust, or safety considerations.

Should the recommended mitigation measures for the construction phase of the WEF development be consistently followed-though, the impact significance would remain *medium* (*negative*) but would entail both positive and negative impacts. Residual negative impacts from inevitable loss of some valuable fossil heritage would be partially offset by an improved palaeontological database for the study region as a direct result of appropriate mitigation.

Given the comparatively small combined footprint of the alternative energy projects in the broader Noupoort region compared with the very extensive outcrop areas of the fossiliferous Balfour and Katberg Formations, the cumulative impact significance of the San Kraal WEF is assessed as LOW.

There are no fatal flaws in the proposed WEF project from a palaeontological heritage viewpoint and no objects to authorisation of the development, provided that the recommended mitigation measures are incorporated into the EMPr for this project and fully implemented.

1. PROJECT DESCRIPTION & BRIEF

The following list of infrastructural components for the proposed San Kraal WEF has been provided by ARCUS Consulting:

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- Up to 78 turbines with a generation capacity between 3 – 5 MW and a rotor diameter of up to 150 m, a hub height of up to 150 m and blade length of up to 75 m;
- Foundations (up to 25 x 25 m) and hardstands associated with the wind turbines;
- Internal access roads of between 8 m (during operation) and 14 m (during construction) wide to each turbine;
- Medium voltage underground electrical cables will be laid to transmit electricity generated by the wind turbines to the on-site switching station or substation;
- Overhead medium voltage cables between turbine rows where necessary;
- An on-site switching station (10 000 m^2);
- An 4 km medium voltage overhead line connecting the on-site switching station with the on-site medium voltage/132 kV substation;
- An on-site substation and OMS complex (180 000 m^2) to facilitate stepping up the voltage from medium to high voltage (132 kV) to enable the connection of the WEF to the proposed Umsobomvu WEF 132/400 kV Substation, and the generated power will be fed into the national grid;
- A 23 km 132 kV high voltage overhead power line from the on-site substation to the proposed 400 kV Umsobomvu substation to the national grid;
- 3 turn-in options of 45 000 m^2 – 450 000m^2 at Eskom MTS SS
- Two 90 000 m^2 alternative areas for batching plants, temporary laydown area and construction compound
- Temporary infrastructure including a site camp; and
- A laydown area approximately 7500 m^2 in extent, per turbine.

The total size of the land portions within which the proposed development will be located is 10 511.51 hectares. The footprint of the proposed development is estimated to be less than 1% of this area

Description	Dimensions		
	Length (m)	Breadth (m)	Area (sqm)
Eskom 400kV Umsobomvu substation	150	150	22500
San Kraal 132/33 kV switching station	150	100	15000
OMS Area	150	50	7500
Construction compound	50	40	2000
Container storage area	50	40	2000

The present combined desktop and field-based palaeontological heritage study of the San Kraal WEF study area contributes to the comprehensive Heritage Impact Assessment and heritage aspects of the Environmental Management Programme for the project compiled under the aegis of ACO Associates cc, Cape Town (Contact details: Mr Tim Hart, ACO Associates cc. Unit D17, Prime Park, 21 Mocke Road, Diep River, 7800. Tel: 021 706 4104. E-mail: Tim.Hart@aco-associates.com). The EIA process for the project is being co-ordinated by Arcus Consulting, Cape Town (Contact details: Ms Ashlin Bodasig and Ms Anja Albertyn, Arcus Consulting, Cape Town, Office 220 Cube Workspace. Cnr Long Street and Hans Strydom Road, Cape Town 8001. Tel: 021 412 1533. E-mail: AnjaA@arcusconsulting.co.za or AshlinB@arcusconsulting.co.za).

2. APPROACH TO THE PALAEONTOLOGICAL HERITAGE STUDY

The approach to this palaeontological heritage study is briefly as follows. Fossil bearing rock units occurring within the broader study area are determined from geological maps and satellite images. Known fossil heritage in each rock unit is inventoried from scientific literature, previous assessments of the broader study region, and the author's field experience and palaeontological database. Based on this data as well as field examination of representative exposures of all major sedimentary rock units present, the impact significance of the proposed development is assessed with recommendations for any further studies or mitigation.

In preparing a palaeontological desktop study the potentially fossiliferous rock units (groups, formations *etc*) represented within the study area are determined from geological maps and satellite images. The known fossil heritage within each rock unit is inventoried from the published scientific literature, previous palaeontological impact studies in the same region, and the author's field experience (consultation with professional colleagues as well as examination of institutional fossil collections may play a role here, or later following field assessment during the compilation of the final report). This data is then used to assess the palaeontological sensitivity of each rock unit to development. The likely impact of the proposed development on local fossil heritage is then determined on the basis of (1) the palaeontological sensitivity of the rock units concerned and (2) the nature and scale of the development itself, most significantly the extent of fresh bedrock excavation envisaged. When rock units of moderate to high palaeontological sensitivity are present within the development footprint, a Phase 1 field assessment study by a professional palaeontologist is usually warranted to identify any palaeontological hotspots and make specific recommendations for any monitoring or mitigation required before or during the construction phase of the development.

On the basis of the desktop and Phase 1 field assessment studies, the likely impact of the proposed development on local fossil heritage and any need for specialist mitigation are determined. Adverse palaeontological impacts normally occur during the construction rather than the operational or decommissioning phase. Phase 2 mitigation by a professional palaeontologist – normally involving the recording and sampling of fossil material and associated geological information (*e.g.* sedimentological data) may be required (a) in the pre-construction phase where important fossils are already exposed at or near the land surface and / or (b) during the construction phase when fresh fossiliferous bedrock has been exposed by excavations. To carry out mitigation, the palaeontologist involved will need to apply for palaeontological collection permits from the relevant heritage management authorities, *i.e..* ECPHRA for the Eastern Cape (ECPHRA contact details: Mr Sello Mokhanya, 74 Alexander Road, King Williams Town 5600; Email: smokhanya@ecphra.org.za) and SAHRA for the Northern Cape (Contact details: SAHRA, 111 Harrington Street, Cape Town. PO Box 4637, Cape Town 8000, South Africa. Phone: +27 (0)21 462 4502. Fax: +27 (0)21 462 4509. Web: www.sahra.org.za). It should be emphasized that, *providing appropriate mitigation is carried out*, the majority of developments involving bedrock excavation can make a *positive* contribution to our understanding of local palaeontological heritage.

2.1. Information sources

The information used in this scoping palaeontological heritage study was based on the following:

1. A short project description, maps and kmz files kindly provided by ARCUS Consulting and ACO Associates, Cape Town;

2. A review of the relevant satellite images, topographical maps and scientific literature, including published geological maps and accompanying sheet explanations, as well as several previous desktop and field-based palaeontological assessment studies in the broader Noupoort – Middelburg study region (*e.g.* Almond 2011, 2012, 2015, 2017, Butler 2014, 2016 and Gess 2012a, 2012b);

3. The author's previous field experience with the formations concerned and their palaeontological heritage;

4. A four-day palaeontological reconnaissance field assessment of the San Kraal WEF project area on 3-6 October 2017 by the author and one assistant.

2.2. Assumptions & limitations

The accuracy and reliability of palaeontological specialist studies as components of heritage impact assessments are generally limited by the following constraints:

1. Inadequate database for fossil heritage for much of the RSA, given the large size of the country and the small number of professional palaeontologists carrying out fieldwork here. Most development study areas have never been surveyed by a palaeontologist.

2. Variable accuracy of geological maps which underpin these desktop studies. For large areas of terrain these maps are largely based on aerial photographs alone, without ground-truthing. The maps generally depict only significant ("mappable") bedrock units as well as major areas of superficial "drift" deposits (alluvium, colluvium) but for most regions give little or no idea of the level of bedrock outcrop, depth of superficial cover (soil *etc*), degree of bedrock weathering or levels of small-scale tectonic deformation, such as cleavage. All of these factors may have a major influence on the impact significance of a given development on fossil heritage and can only be reliably assessed in the field.

3. Inadequate sheet explanations for geological maps, with little or no attention paid to palaeontological issues in many cases, including poor locality information.

4. The extensive relevant palaeontological "grey literature" - in the form of unpublished university theses, impact studies and other reports (*e.g*. of commercial mining companies) - that is not readily available for desktop studies.

5. Absence of a comprehensive computerized database of fossil collections in major RSA institutions which can be consulted for impact studies. A Karoo fossil vertebrate database is now accessible for impact study work.

In the case of palaeontological desktop studies without supporting Phase 1 field assessments these limitations may variously lead to either:

(a) *underestimation* of the palaeontological significance of a given study area due to ignorance of significant recorded or unrecorded fossils preserved there, or

(b) *overestimation* of the palaeontological sensitivity of a study area, for example when originally rich fossil assemblages inferred from geological maps have in fact been destroyed by tectonism or weathering, or are buried beneath a thick mantle of unfossiliferous "drift" (soil, alluvium *etc*).

Since most areas of the RSA have not been studied palaeontologically, a palaeontological desktop study usually entails *inferring* the presence of buried fossil heritage within the study area from relevant fossil data collected from similar or the same rock units elsewhere, sometimes at localities far away. Where substantial exposures of bedrocks or potentially fossiliferous superficial sediments are present in the study area, the reliability of a palaeontological impact assessment may be significantly enhanced through field assessment by a professional palaeontologist.

In the case of the San Kraal WEF study area near Noupoort in the Northern and Eastern Cape preservation of potentially fossiliferous bedrocks is favoured by the semi-arid climate and sparse vegetation but bedrock exposure is very limited by extensive superficial deposits (sandy soils, scree), especially in areas of low relief such as the plateau areas where the majority of the WEF infrastructure will be placed. Vehicle access to most of the upland plateau areas is currently challenging and very limited.

In practice, approximately two thirds of the fieldwork time was spent traversing the core WEF project area on the Katberg sandstone plateau – uniformly regarded as palaeontologically uninformative due to superficial sediment cover - and perhaps some 10% of time in the powerline project area. However, it is considered that sufficient bedrock and cover sediment exposures were examined during the course of this study to assess the broader palaeontological heritage sensitivity of the study area (See Appendix). Comparatively few academic palaeontological studies or field-based fossil heritage impact studies have been carried out in the region, so any new data from impact studies here are of scientific interest.

2.3. Legislative context for palaeontological assessment studies

The San Kraal WEF alternative energy project is located in an area that is underlain by potentially fossiliferous sedimentary rocks of Late Palaeozoic to Mesozoic and younger, Late Tertiary or Quaternary, age (Sections 3 and 4). The construction phase of the proposed development will entail substantial excavations into the superficial sediment cover and locally into the underlying bedrock as well. These include, for example, excavations for the wind turbine foundations, hard standing areas, internal access roads, underground cables, transmission line pylon footings, electrical substations, operations and services workshop area/office building, laydown areas and construction site camp. All these developments may adversely affect potential fossil heritage within the study area by destroying, disturbing or permanently sealing-in fossils at or beneath the surface of the ground that are then no longer available for scientific research or other public good. The operational and decommissioning phases of the wind energy facility are unlikely to involve further adverse impacts on local palaeontological heritage, however.

The present combined desktop and field-based palaeontological heritage study contributes to the consolidated Heritage Assessment for the San Kraal WEF project and falls under the South African Heritage Resources Act (Act No. 25 of 1999). It will also inform the Environmental Management Programme for this project.

The various categories of heritage resources recognised as part of the National Estate in Section 3 of the National Heritage Resources Act include, among others:

- geological sites of scientific or cultural importance;
- palaeontological sites;
- palaeontological objects and material, meteorites and rare geological specimens.

According to Section 35 of the National Heritage Resources Act, dealing with archaeology, palaeontology and meteorites:

(1) The protection of archaeological and palaeontological sites and material and meteorites is the responsibility of a provincial heritage resources authority.

(2) All archaeological objects, palaeontological material and meteorites are the property of the State.

(3) Any person who discovers archaeological or palaeontological objects or material or a meteorite in the course of development or agricultural activity must immediately report the find to the responsible heritage resources authority, or to the nearest local authority offices or museum, which must immediately notify such heritage resources authority.

(4) No person may, without a permit issued by the responsible heritage resources authority—

(a) destroy, damage, excavate, alter, deface or otherwise disturb any archaeological or palaeontological site or any meteorite;

(b) destroy, damage, excavate, remove from its original position, collect or own any archaeological or palaeontological material or object or any meteorite;

(c) trade in, sell for private gain, export or attempt to export from the Republic any category of archaeological or palaeontological material or object, or any meteorite; or

(d) bring onto or use at an archaeological or palaeontological site any excavation equipment or any equipment which assist in the detection or recovery of metals or archaeological and palaeontological material or objects, or use such equipment for the recovery of meteorites.

(5) When the responsible heritage resources authority has reasonable cause to believe that any activity or development which will destroy, damage or alter any archaeological or palaeontological site is under way, and where no application for a permit has been submitted and no heritage resources management procedure in terms of section 38 has been followed, it may—

(a) serve on the owner or occupier of the site or on the person undertaking such development an order for the development to cease immediately for such period as is specified in the order;

(b) carry out an investigation for the purpose of obtaining information on whether or not an archaeological or palaeontological site exists and whether mitigation is necessary;

(c) if mitigation is deemed by the heritage resources authority to be necessary, assist the person on whom the order has been served under paragraph *(a)* to apply for a permit as required in subsection (4); and

(d) recover the costs of such investigation from the owner or occupier of the land on which it is believed an archaeological or palaeontological site is located or from the person proposing to undertake the development if no application for a permit is received within two weeks of the order being served.

Minimum standards for the palaeontological component of heritage impact assessment reports (PIAs) have recently been published by SAHRA (2013).

3. GEOLOGICAL CONTEXT

The San Kraal WEF study area is situated in dissected, semi-arid mountainous terrain of the Agter-Renosterberg – Kikvorsberg Ranges which are situated within the Upper Karoo geomorphic province of the RSA (Partridge *et al.* 2010). The core WEF development area where most of the infrastructure will be situated, including wind turbines and access roads, is located on an undulating, grassy sandstone plateau reaching elevations of *c*. 1840 m amsl. (Figs. 5, 6, 33 & 34). The steep margins of the plateau are incised by several narrow stream valleys reflecting erosional down-cutting during more pluvial periods in the geological past.

The geology of the Noupoort study region is shown on 1: 250 000 sheet 3124 Middelburg (Cole *et al.* 2004) (Fig. 2) and has been briefly described in a previous WEF palaeontological assessment for the Noupoort area by Almond (2012). Most of the study area, including the core development area, is underlain by Early Triassic (*c*. 250 Ma = million years old) fluvial sediments of the **Katberg Formation** (**TRk**, yellow with red stipple in Fig. 2) which forms the lowermost subunit of the Tarkastad Subgroup (Upper Beaufort Group, Karoo Supergroup). Levels of tectonic deformation in this region are very low, as shown by recorded dips here of only two to three degrees within the Tarkastad Subgroup, with most of the succession being subhorizontal.

Very small outcrop areas of Karoo sediments assigned to the underlying **Adelaide Subgroup** (**Pa**, pale blue in Fig. 2) are mapped in the western foothills of the Kikvorsberg close to the N9 and Noupoort town. These older bedrocks belong to the uppermost portion of the **Balfour Formation**, namely the **Palingkloof Member** of Latest Permian to Earliest Triassic age. According to Cole *et al.* (2004) this succession consists largely of reddish mudrocks and has a thickness of only some 20 m or so in the Noupoort area (*e.g.* Carlton Siding). Given their location at the foot of the Katberg escarpment, the Adelaide Subgroup rocks here are largely covered by colluvial debris (gravelly scree, hillwash sands) and are furthermore unlikely to be directly impacted by the Noupoort wind farm development, with the possible exception of a access roads in lowland areas. For these reasons, the Balfour Formation rocks will not be treated in any detail in this study. It should be noted, however, that they are of considerable palaeontological significance elsewhere in the Main Karoo Basin since they record the catastrophic end-Permian mass extinction event and ensuing biotic recovery among continental biotas (*e.g.* Smith & Ward 2001, Smith *et al.* 2002, Retallack *et al.* 2003 and 2006, Ward *et al.* 2005, Smith & Botha 2005, Botha & Smith 2007, Smith & Botha-Brink 2014, Smith *et al.* 2012). Good erosion gulley exposures of Palingkloof Member mudrocks and thin-bedded sandstones are seen on Hartebeest Hoek 182, just outside the San Kraal WEF study area (Fig. 3).

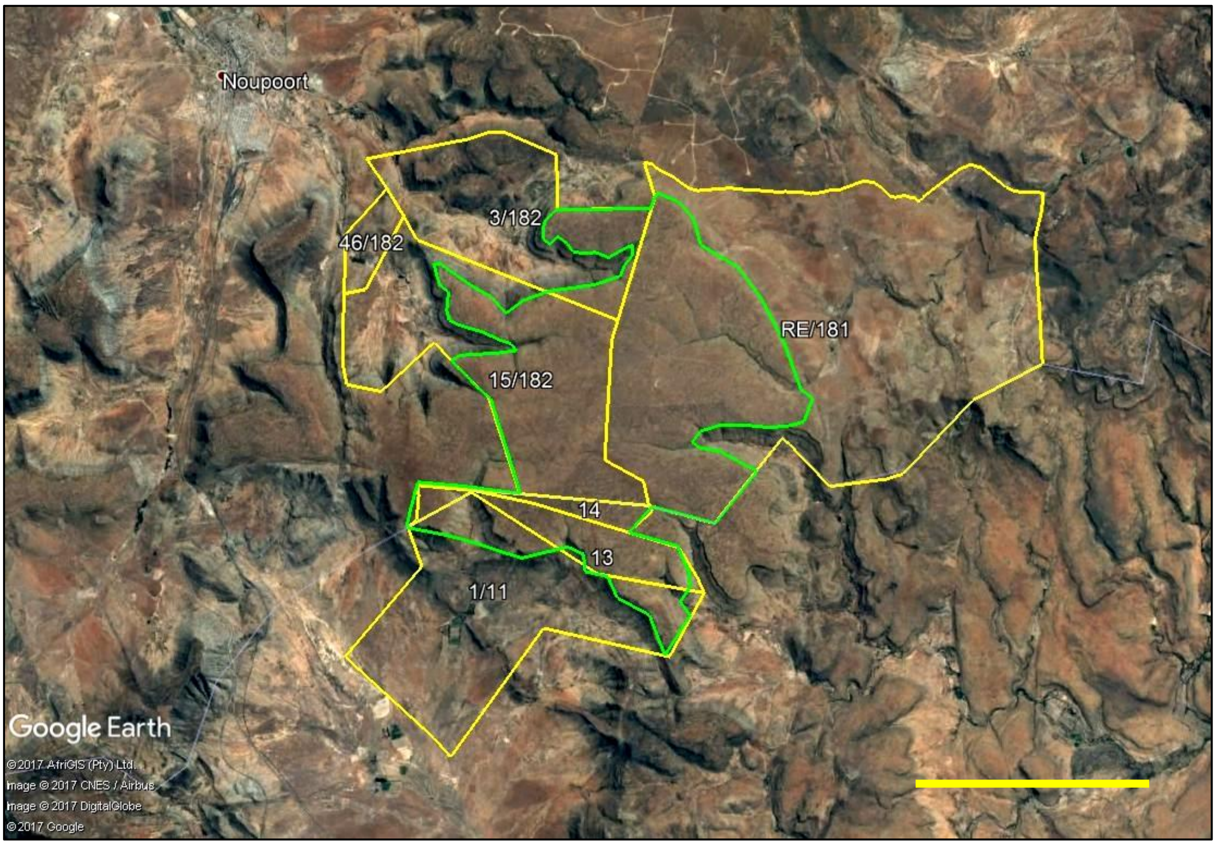

Fig. 1. Google Earth© satellite image of the region to the south-east of Noupoort showing the study area for the proposed San Kraal WEF (yellow polygon) as well as an outline of plateau areas where the majority of the WEF infrastructure will be sited (green polygon). Scale bar = 5 km. North towards the top of the image.

The Katberg Formation forms the regionally extensive, sandstone-rich lower portion of the Tarkastad Subgroup (Upper Beaufort Group) that can be traced throughout large areas of the Main Karoo Basin. In the Middelburg sheet area it reaches a maximum thickness of some 400 m, but close to Noupoort thicknesses of 240-260 m are more usual. The predominant sediments are (a) prominent-weathering, pale buff to greyish, tabular or ribbon-shaped sandstones up to 60 m thick (Figs. 4, 7 & 8) that are interbedded with (b) recessive-weathering, reddish or occasionally green-grey mudrocks (Figs. 17 & 18). Up to four discrete sandstone packages can be identified within the succession. In the Noupoort area the overall sandstone:mudrock ratio is close to 1:1. Katberg channel sandstones are typically rich in feldspar and lithic grains (*i.e.* lithofeldspathic). They build laterally extensive, tabular, multi-storey units with an erosional base that is often marked by intraformational conglomerates up to one meter or more thick consisting of mudrock pebbles, reworked calcrete nodules and occasional rolled fragments of bone (Figs. 14 to 16, 30). While the basal Katberg succession is often marked by a major cliff-forming sandstone unit, in the Noupoort area there is a transitional relationship with the underlying Adelaide Subgroup that is marked by a broadly upward-thickening series of sandstone sheets (Fig. 4). The cliff-forming uppermost part of the Katberg Formation in the study area that underlies the plateau areas is composed of amalgamated channel sandstone facies with only a small proportion of overbank mudrocks. Internally the moderately well-sorted sandstones are variously massive, horizontally-laminated or tabular to trough cross-bedded while heavy mineral laminae occur frequently. Sphaeroidal carbonate concretions up to 10 cm across, sometimes secondarily ferruginised, are common. The predominantly purple-brown Katberg mudrocks are typically massive with horizons of pedocrete nodules (calcretes) and mudcracks but packages of thin-bedded grey-green and purple-brown mudrocks passing up into heterolithic successions of interbedded grey-green fine sandstone and siltstone are also occasionally seen (Fig. 17). Mudrock exposure within the study area is very limited indeed due to extensive mantling of these recessive-weathering rocks by superficial sediments (soils, scree, downwasted gravels, hillwash *etc*).

The highland plateau areas that form the great majority of the WEF project area vary from fairly grassy and featureless to rugged terrain with numerous low kranzes and pavements of Katberg sandstone (Figs. 5 to 7, 9). Karstic (solution-weathering) features such as polygonal cracks (tessellation / alligator cracking), rock basins (*gnammas*) and rock doughnuts are well-developed on some of the better-exposed sandstone *kranzes* and sandstone pavements in these (*cf* Grab *et al.* 2011) (Figs. 10 to 12). Another interesting feature observed on weathered sandstone surfaces are shallow subcircular to irregular etched depressions generated by epilithic lichens that have been well-studied on younger Clarens Formation feldspathic sandstones in the Golden Gate National Park (*ibid*. and refs. therein) (Fig. 13). The lichen etching appears to postdate the karstic weathering and associated case-hardening and continues to the present day, especially on more shaded, south-facing surfaces.

The Karoo Supergroup sedimentary rocks in the Noupoort study area are extensively intruded by Early Jurassic (183 ± 2 Ma) igneous intrusions of the **Karoo Dolerite Suite** (**Jd**) (Cole *et al.* 2004, Duncan & Marsh 2006) (Fig. 19). The sills and dykes have thermally metamorphosed or baked the adjacent mudrocks and sandstones to resistant-weathering hornfels and quartzite respectively (Figs. 20-21).

In most parts of the study area, including both the flatter-lying plateau regions and low-lying *vlaktes* as well as steeper hillslopes, the Permo-Triassic bedrocks are mantled with a variety of **superficial deposits** of probable Late Caenozoic (mostly Quaternary to Recent) age. A wedge-shaped prism or apron of sandy to gravelly colluvium and hillwash mantles the foot of the Katberg escarpment (piedmont fans) (Fig. 23), while the escarpment slopes themselves are largely obscured by sandstone scree, apart from the thicker, prominent-weathering Katberg channel sandstone bodies (Fig. 4). Thick sandy to gravelly alluvial deposits are encountered in more major stream valleys at the foot of the Katberg escarpment, where they are often incised by deep erosional *dongas*, while thick sandy alluvium is seen in shallow palaeovalleys on the plateaux (Figs. 24 & 25). The Katberg sandstones underlying the buildable plateau areas in the study region are largely overlain by thin, orange-brown sandy soils as well as angular, poorly-sorted gravels of downwasted sandstone (Fig. 22). Well-developed Late Caenozioc pedocretes (*e.g.* calcrete) were not encountered during the field study, although modest creamy calcrete is seen locally in the vicinity of dolerite intrusions.

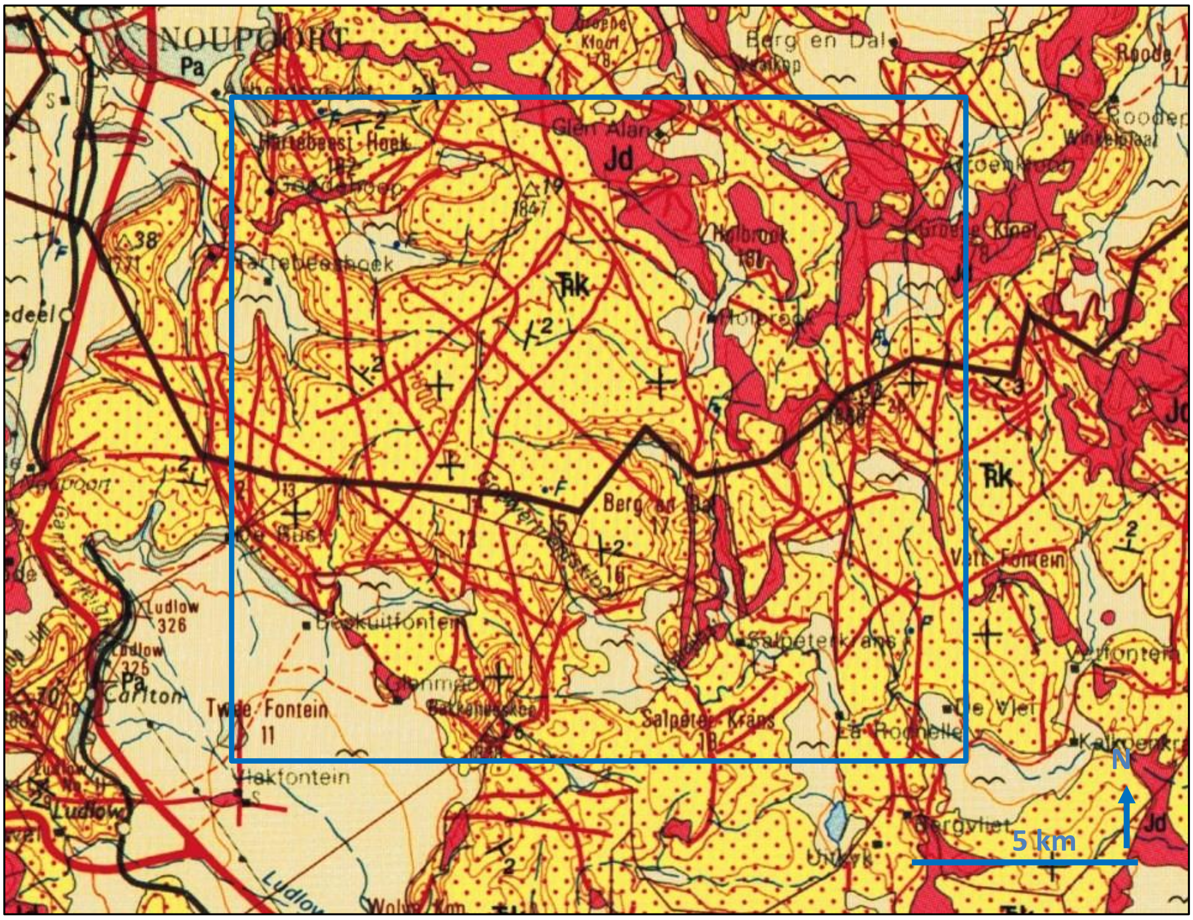

Fig. 2. Extract from 1: 250 000 geology sheet 3124 Middelburg (Council for Geoscience, Pretoria) showing *approximate* outline of the San Kraal WEF study area to the southeast of Noupoort, Northern & Eastern Cape (blue rectangle). The main geological units represented here are:

Pa (pale blue) = Late Permian to Earliest Triassic Adelaide Subgroup (Lower Beaufort Group, Karoo Supergroup)
TRk (yellow with red stipple) = Early Triassic Katberg Formation of the Tarkastad Subgroup (Upper Beaufort Group, Karoo Supergroup)
Jd (red) = Early Jurassic Karoo Dolerite Suite
Pale brown areas with “flying bird”symbol = Quaternary to Recent alluvium

***N.B.* Other Caenozoic superficial deposits such as colluvium (scree *etc*), soils and surface gravels are not depicted here but in fact cover much of the landscape.**

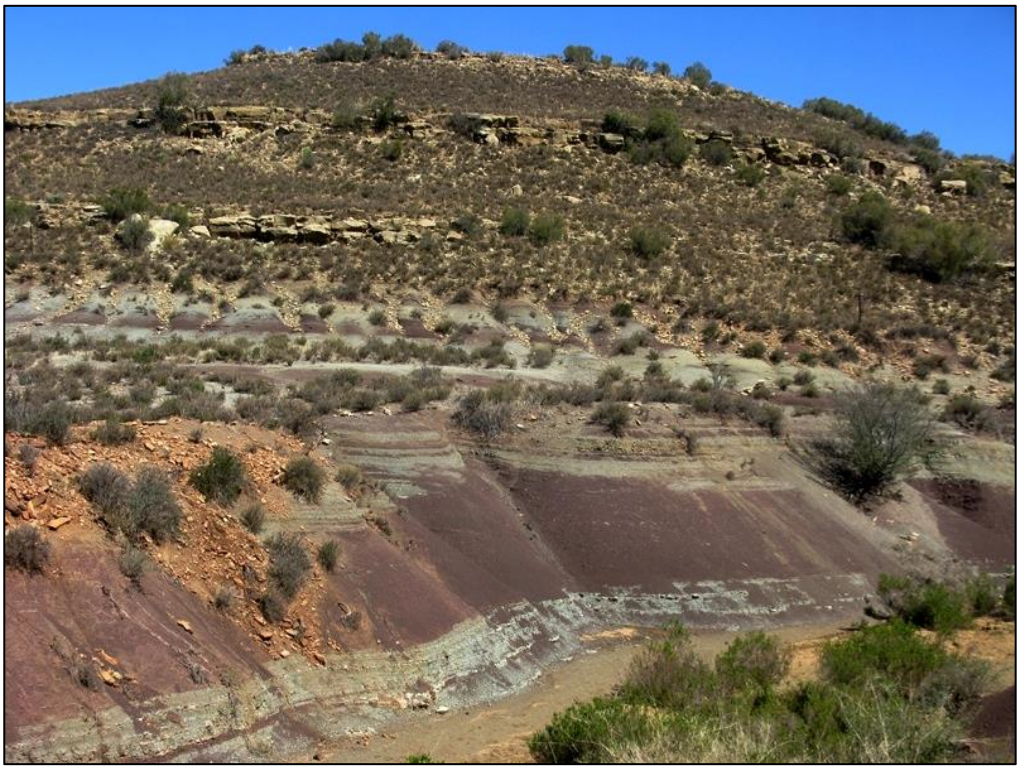

Fig. 3. Excellent erosion gulley and hillslope exposures of colour-banded overbank mudrocks and thin sandstones of the uppermost Balfour Formation (Palingkloof Member) underlying the prominent-weathering channel sandstones of the Katberg Formation, Hartebeest Hoek 182 (Loc. 073).

Fig. 4. Northwest-facing escarpment of the Katberg Formation on the southern side of Oorlogspoort, Hartebeest Hoek 182, showing spaced, laterally-persistent channel sandstones with intervening overbank mudrocks largely obscured by sandstone scree (Loc. 023). Note cliff of amalgamated Katberg channel sandstones on the horizon.

Fig. 5. View north-eastwards across grassy upland plateau on Farm RE14 showing area with very little bedrock exposure (Loc. 038). Surface mantled by sandy soils and downwasted sandstone gravels.

Fig. 6. Sandstone plateau area on Holbrook 181 showing shallow incised stream valley, rocky Katberg sandstone outcrops and rubbly sandstone surface rubble (Loc. 055).

Fig. 7. ***Kranz*** **built by thick cross-bedded Katberg channel sandstones on Tweefontein 1/11 (Loc. 033).**

Fig. 8. Large scale tabular current cross-bedding within the Katbeg Formation on Holbrook 181 (Loc. 048).

Fig. 9. Extensive Katberg sandstone pavement on Hartebeest Hoek 182 showing large-scale jointing as well as karstic weathering features (Loc. 063).

Fig. 10. Detail of pavement seen in previous illustration to show polygonal jointing, shallower surface cracks as well as solution hollows (Loc. 063).

Fig. 11. Typical karstic tessellation or alligator cracking shown by Katberg sandstone surface on Tweefontein 1/11 (Loc. 036) (Scale = 15 cm).

Fig. 12. Small, steep-sided rock basin or *gnamma* resulting from karstic weathering of Katberg sandstone on farm RE14 (Loc. 038).

Fig. 13. Good example of lichen weathering on Katberg sandstone surface, Holbrook 181 (Loc. 046) (Scale is *c.* 15 cm long).

Fig. 14. Cross-bedded, secondarily-ferruginised, fine-grained calcrete channel breccio-conglomerate at the base of a thick Katberg channel sandstone, Hartebeest Hoek 182 (Loc. 069) (Hammer = 27 cm).

Fig. 15. Extensive exposure of thick, greyish calcrete nodule breccio-conglomerate within Katberg Formation on Holbrook 181 (Loc. 045) (Hammer = 27 cm). The breccio-conglomerate contains sparse reworked bone and tooth fragments (See Fig. 30).

Fig. 16. Thick coarse mudstone intraclast breccio-conglomerates towards base of a Katberg channel sandstone, Ooorlogspoort, Hartebeest Hoek 182 (Loc. 062) (Hammer = 27 cm).

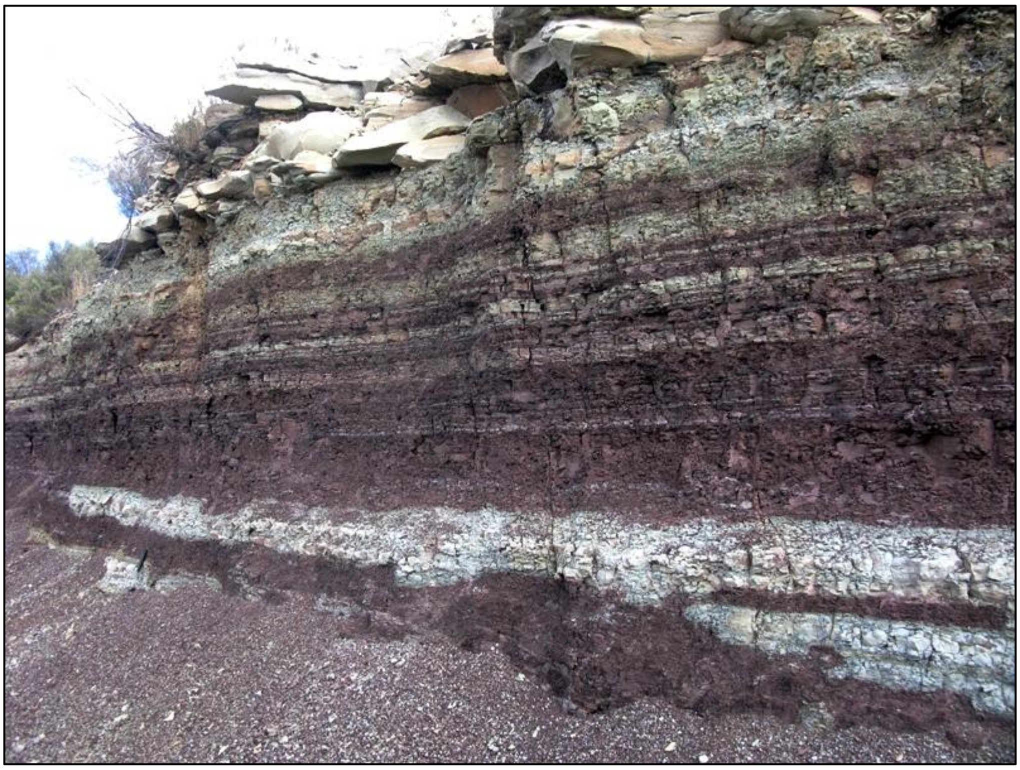

Fig. 17. Upward-coarsening package of irregularly colour-banded overbank mudrocks and thin-bedded sandstones exposed in a borrow pit in Oorlogspoort, Hartebeest Hoek 182 (Loc. 056) (Hammer = 27 cm).

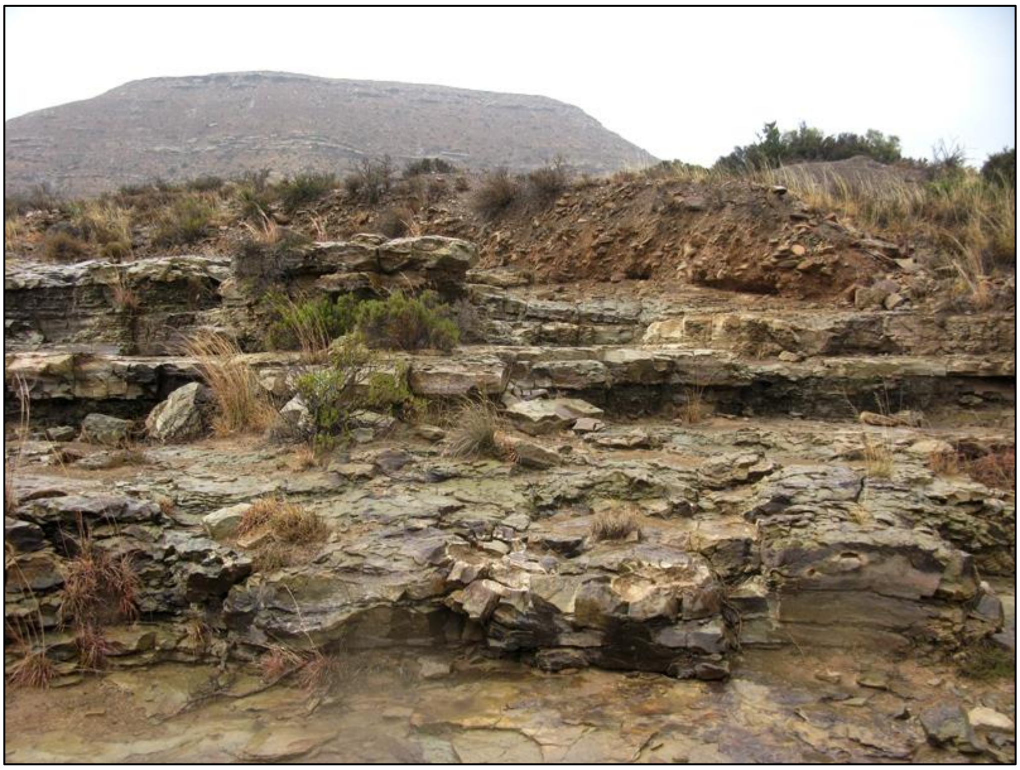

Fig. 18. Streambed exposure of interbedded thin crevasse-splay sandstones and grey-green overbank mudrocks, probably within the lower Katberg Formation, Tweefontein 1/11 (Loc. 029). Note overlying thick alluvial gravels.

Fig. 19. Typical rubbly weathering with boulder-sized corestones of dolerite dyke intruding the Lower Beaufort Group country rocks on Hartebeest Hoek 182 (Loc. 026).

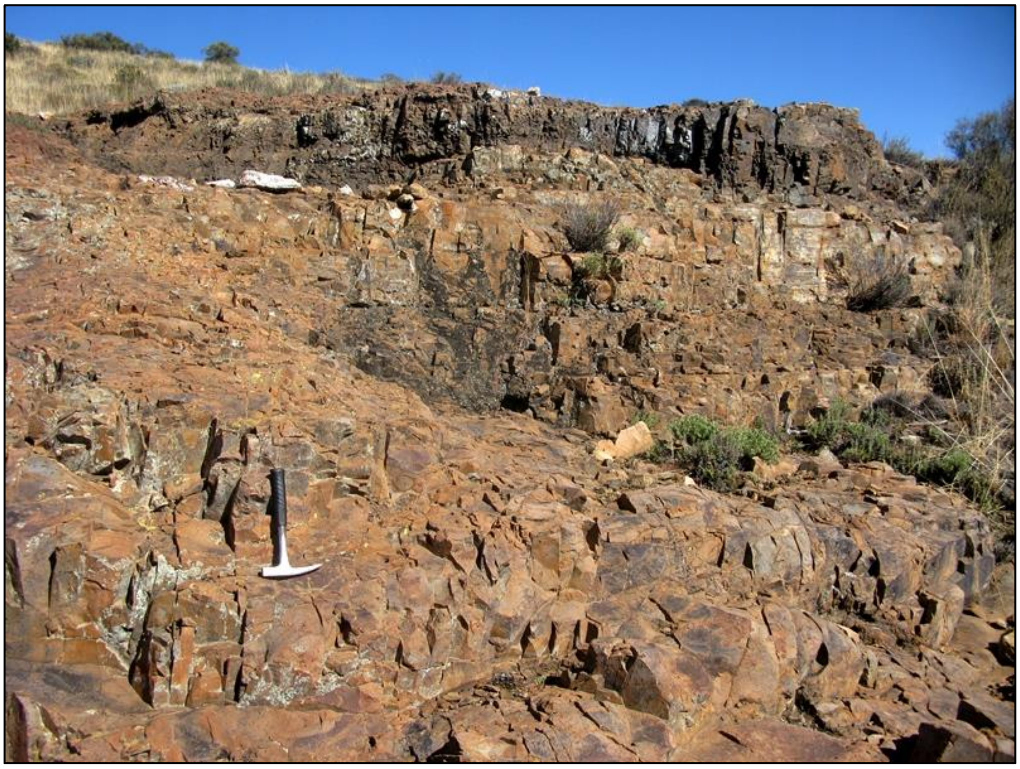

Fig. 20. Thick, columnar-jointed dolerite dyke containing baked rafts or xenoliths of Katberg sedimentary rocks, Hartebeest Hoek 182 (Loc. 060) (Hammer = 27 cm).

Fig. 21. Katberg thin-bedded channel sandstone sharply overlying dark grey overbank mudrocks, here baked by dolerite intrusion to form quartzite and hornfels, Hartebeest Hoek 182 (Loc. 071) (Hammer = 27 cm).

Fig. 22. Downwasted surface gravels of sandstone overlying Katberg sandstone pavement, Tweefontein 1/11 (Loc. 035).

Fig. 23. Thick, eroded piedmond fan of sandy and gravelly colluvial and alluvial deposits mantling foot of the Katberg escarpment, Hartebeest Hoek 182 (Loc. 025).

Fig. 24. Erosion gulley exposure of thick sandy alluvium in stream valley on Katberg plateau, Holbrook 181 (Loc. 049) (Hammer = 27 cm).

Fig. 25. Sandy soils with well-developed stone line overlying weathered Katberg mudrocks and overlain in turn by dark grey modern carbonaceous soils, Farm RE13 (Loc. 037) (Hammer = 27 cm).

4. PALAEONTOLOGICAL HERITAGE

The fossil heritage within each of the major rock units that are represented within the San Kraal WEF study area is outlined here, together with a brief account of Beaufort Group fossil records from the Noupoort region itself. Note that a separate account of fossils from the uppermost Adelaide Subgroup (Pa) is not given because the upper part of the Palingkloof Member (Balfour Formation) belongs to the same assemblage zone (*i.e.* the *Lystrosaurus* AZ) as the overlying Katberg Formation. Occasional limited exposures of Palingkloof Member rocks were identified in the field (Fig. 3) but these do not fall within the WEF project area and are very unlikely to be impacted by the proposed development.

GPS data for geological and fossil localities mentioned in the text and figure legends are provided separately in the Appendix to this report.

4.1. Fossil heritage in the Katberg Formation and uppermost Adelaide Subgroup

The Katberg Formation is known to host a diverse and palaeontologically important terrestrial fossil biota of Early Triassic (Scythian / Induan - Early Olenekian) age, *i.e.* around 252 million years old (Groenewald & Kitching 1995, Rubidge 2005, Smith *et al.* 2012). The biota is dominated by a range of therapsids ("mammal-like reptiles"), amphibians and other tetrapods, with rare vascular plants and trace fossils, and has been assigned to the ***Lystrosaurus* Assemblage Zone** (**LAZ**). This surprisingly rich fossil assemblage characterizes Early Triassic successions of the upper part of the Palingkloof Member

(Adelaide Subgroup) as well as the Katberg Formation. It should also be noted that while the dicynodont *Lystrosaurus* is also recorded from the uppermost beds of the Latest Permian *Dicynodon* Assemblage Zone it only becomes super-abundant in Early Triassic times (*e.g.* Smith & Botha 2005, Botha & Smith 2007 and refs. therein).

Useful illustrated accounts of LAZ fossils are given by Kitching (1977), Keyser and Smith (1977-1978), Groenewald and Kitching (1995), MacRae (1999), Hancox (2000), Smith *et al.* (2002), Cole *et al*. (2004), Rubidge (2005 *plus* refs therein), Damiani *et al.* (2003a), Smith *et al.* (2012) among others. These fossil biotas are of special palaeontological significance in that they document the recovery phase of terrestrial ecosystems following the catastrophic end-Permian Mass Extinction of 252 million years ago (*e.g.* Smith & Botha 2005, Gastaldo *et al.* 2005, Botha & Smith 2007, Smith & Botha-Brink 2014 and refs. therein). They also provide interesting insights into the adaptations and taphonomy of terrestrial animals and plants during a particularly stressful, arid phase of Earth history in the Early Triassic.

Key tetrapods in the *Lystrosaurus* Assemblage Zone biota are various species of the medium-sized, shovel-snouted dicynodont *Lystrosaurus* (by far the commonest fossil form in this biozone. contributing up to 95% of fossils found), the small captorhinid parareptile *Procolophon*, the crocodile-like early archosaur *Proterosuchus*, and a wide range of small to large armour-plated "labyrinthodont" amphibians such as *Lydekkerina* (Figs. 26 and 27). Botha and Smith (2007) have charted the ranges of several discrete *Lystrosaurus* species either side of the Permo-Triassic boundary. Also present in the LAZ are several genera of small-bodied true reptiles (*e.g.* owenettids), therocephalians, and early cynodonts (*e.g. Galesaurus, Thrinaxodon*). Animal burrows are attributable to various aquatic and land-living invertebrates, including arthropods (*e.g. Scoyenia* and *Katbergia* scratch burrows), as well as several subgroups of fossorial tetrapods such as cynodonts, procolophonids and even *Lystrosaurus* itself (*e.g.* Groenewald 1991, Damiani *et al.* 2003b, Abdala *et al.* 2006, Modesto & Brink 2010, Bordy *et al.* 2009, 2011). Vascular plant fossils are generally rare and include petrified wood ("*Dadoxylon*") as well as leaves of glossopterid progymnosperms and arthrophyte ferns (*Schizoneura*, *Phyllotheca*). An important, albeit poorly-preserved, basal Katberg palaeoflora has recently been documented from the Noupoort area (Carlton Heights) by Gastaldo *et al.* (2005). Plant taxa here include sphenopsid axes, dispersed fern pinnules and possible peltasperm (seed fern) reproductive structures. Pebbles of reworked silicified wood of possible post-Devonian age occur within the Katberg sandstones in the proximal outcrop area near East London (Hiller & Stavrakis 1980, Almond unpublished obs.). Between typical fossil assemblages of the *Lystrosaurus* and *Cynognathus* Assemblage Zones lies a possible *Procolophon* Acme Zone characterized by abundant material of procolophonids and of the amphibian *Kestrosaurus* but lacking both *Lystrosaurus* and *Cynognathus* (Hancox 2000 and refs. therein).

Most vertebrate fossils are found in the mudrock facies rather than channel sandstones. Articulated skeletons enclosed by calcareous pedogenic nodules are locally common, while intact procolophonids, dicynodonts and cynodonts have been recorded from burrow infills (Groenewald and Kitching, 1995). Fragmentary rolled bone and teeth (*e.g.* dicynodont tusks) are found in the intraformational calcrete nodule conglomerates at the base of some the channel sandstones. Vertebrate burrows occur within both mudrock and sandstone facies.

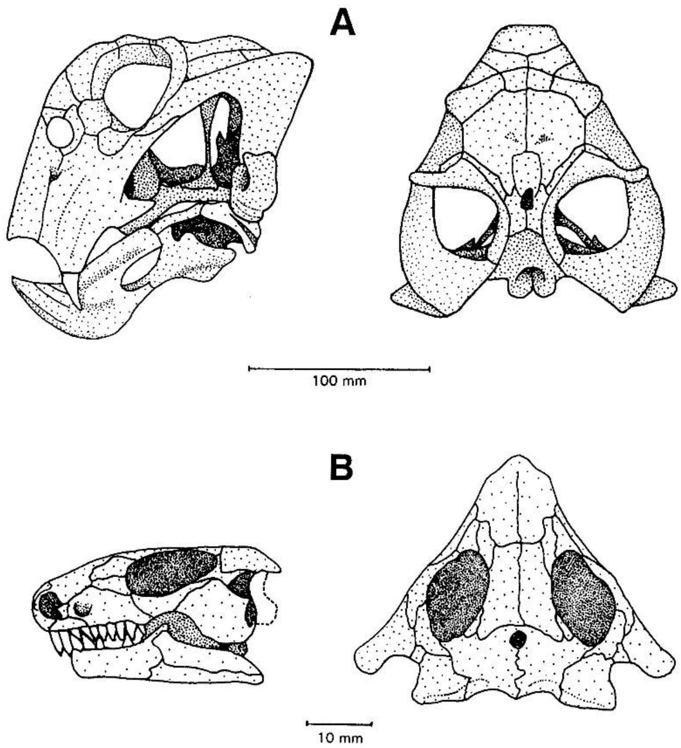

Fig. 26. Skulls of two key tetrapod genera from the Early Triassic *Lystrosaurus* Assemblage Zone of the Main Karoo Basin: the pig-sized dicynodont *Lystrosaurus* (A) and the small primitive reptile *Procolophon* (B) (From Groenewald and Kitching, 1995).

Several Karoo vertebrate fossil sites are reported from the Katberg Formation and underlying rocks in the Middelburg – Noupoort region by Kitching (1977; see Karoo biozonation map in Fig. 28 herein as well as updated Karoo vertebrate fossil site map of Nicolas 2007 abstracted in Fig. 29). For example, Kitching recorded as many as five different species of *Lystrosaurus* from good mountain slope exposures as well as road and railway cuttings in the Carlton Heights area near Noupoort. Abundant lystrosaurids, including three species of the genus, were found at Edenvale and on Noupoort Commonage (*ibid*., pp. 89-100). It is interesting that the spectrum of *Lystrosaurus* species recorded by Kitching (1977) in the Noupoort region – if correctly identified - suggests that Latest Permian beds referable to the *Dicynodon* Assemblage Zone may in fact be present here (*cf.* Botha & Smith 2007). This is supported by a recent search for fossil records from the Noupoort area in the Karoo fossil database at the BPI (Wits University) kindly undertaken by Mr Mike Day. Sites on the farms Naauwport 1, Bergendal 179, New Jakkalsfontein 172 and Carolus Poort 167 have yielded abundant material of *Lystrosaurus* together with *Procolophon*, *Tetracynodon* and a few specimens of *Dicynodon*. An unusually diverse LAZ assemblage has recently been recorded from Barendskraal near Middelburg by Damiani *et al.* (2003a). The spectrum of nine or more tetrapod species found here includes *Lystrosaurus* (albeit with low abundance), therocephalians, archosaurs and several procolophonid reptiles. The poorly-preserved fossil flora recorded by Gastaldo *et al.* (2005) from the basal Katberg at Carlton Heights near Noupoort is of special interest because plant fossils are so rare in this stratigraphic interval. Scrappy compressions of reedy plants within Katberg sandstones were illustrated by Almond (2015) from the Umsobomvu WEF project area southwest of Noupoort.

Sparse, highly-weathered postcranial remains as well as poorly-preserved *Lystrosaurus* skull material was reported just to the SW of Noupoort by Butler (2014). Gess (2012b) recorded locally abundant vertebrate body fossils, including *Lystrosaurus* and a small cynodont, plant stems, vertebrate burrows and *Katbergia* ("roots") on Portion 1 of Naauw Poort Farm 1 located *c*. 11 km south of Noupoort. On farm Blydefontein 168, situated just to the north of the San Krall WEF study area, Almond (2012) recorded fragmentary reworked skeletal remains, including disarticulated skulls, postcrania and teeth (especially dicynodont tusks) within greyish calcrete conglomerates. Some of the fossils were clearly encased in ferruginous pedogenic calcrete *before* they were exhumed and reworked. Overlying massive grey-green siltstones contain rare "bone-bed" concentrations (*e.g. Lystrosaurus* skull and postcrania) and horizons of large ferruginous calcrete nodules representing palaeosols. A small number of, mostly fragmentary, vertebrate fossils were reported from Katberg overbank mudrocks and calcrete breccia beds in the Umsobomvu WEF study area southwest of Noupoort by Almond (2015); they did include one well-articulated lystrosaurid skeleton with associated skull, however.

Low-diversity trace fossil assemblages recorded from Katberg rocks in the Noupoort area – for example south of the Oologspoort road - include locally abundant vertical cyclindrical structures attributed to *Skolithos* in the literature (*e.g.* Almond 2012) but more plausibly interpreted as plant stem casts, as well as small meniscate back-filled burrows ("*Taenidium*"). Numerous examples of the cm-wide subcylindrical invertebrate burrow *Katbergia* were observed by Almond (2012) in fresh road cuttings through the Katberg Formation along the N9 at Carlton Heights and localities further to the SW (Gess 2012, Almond 2015). These distinctive burrows penetrate down through grey-green mudrocks at an oblique angle and show surface scratch markings; they have been tentatively attributed to decapod crustaceans (Gastaldo & Rolerson 2008, Bordy *et al.* 2010). Several much larger, straight, gently-sloping vertebrate burrow casts cutting down through thin-bedded overbank mudrocks within the lower Katberg Formation are recorded from road cuttings on farm Naauw Poort 1 (Almond 2015). Further vertebrate burrow casts recorded on farm Winterhoek 118 are described and illustrated in the palaeontological report for the Phezukomoya WEF southwest of Noupoort (Almond 2017).

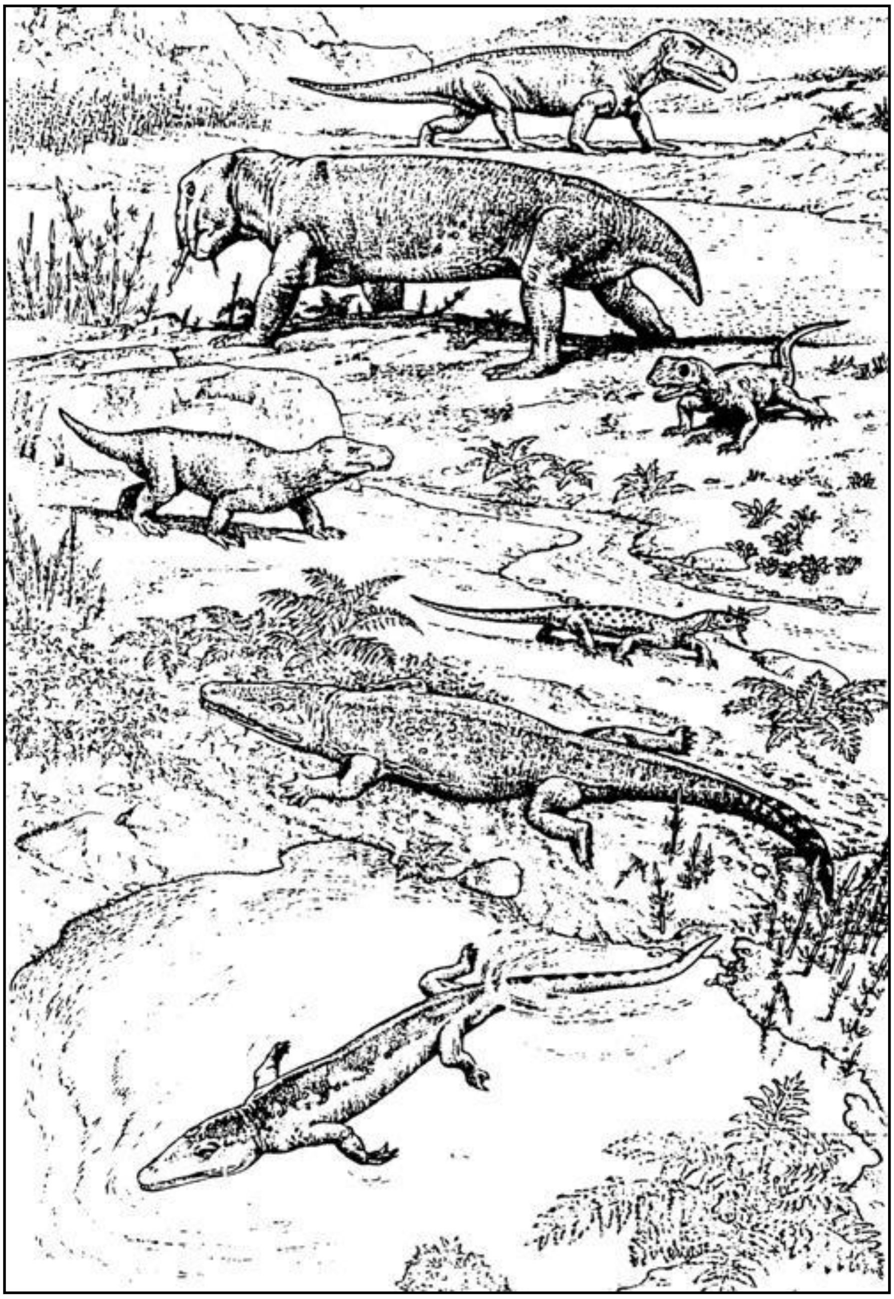

Fig. 27. Reconstruction of Early Triassic biotas of the *Lystrosaurus* Assemblage Zone (From Benton 2003 *When life nearly died*). Animals illustrated here include the crocodile-like archosaur reptile *Proterosuchus* (top) and below this the dominant, pig-sized dicyndont *Lystrosaurus*, a small predatory therocephalian therapsid (middle left), several small lizard-like reptiles such as procolophonids (middle right), and two large amphibians (bottom). Plants shown here include several ferns and reedy horsetails.

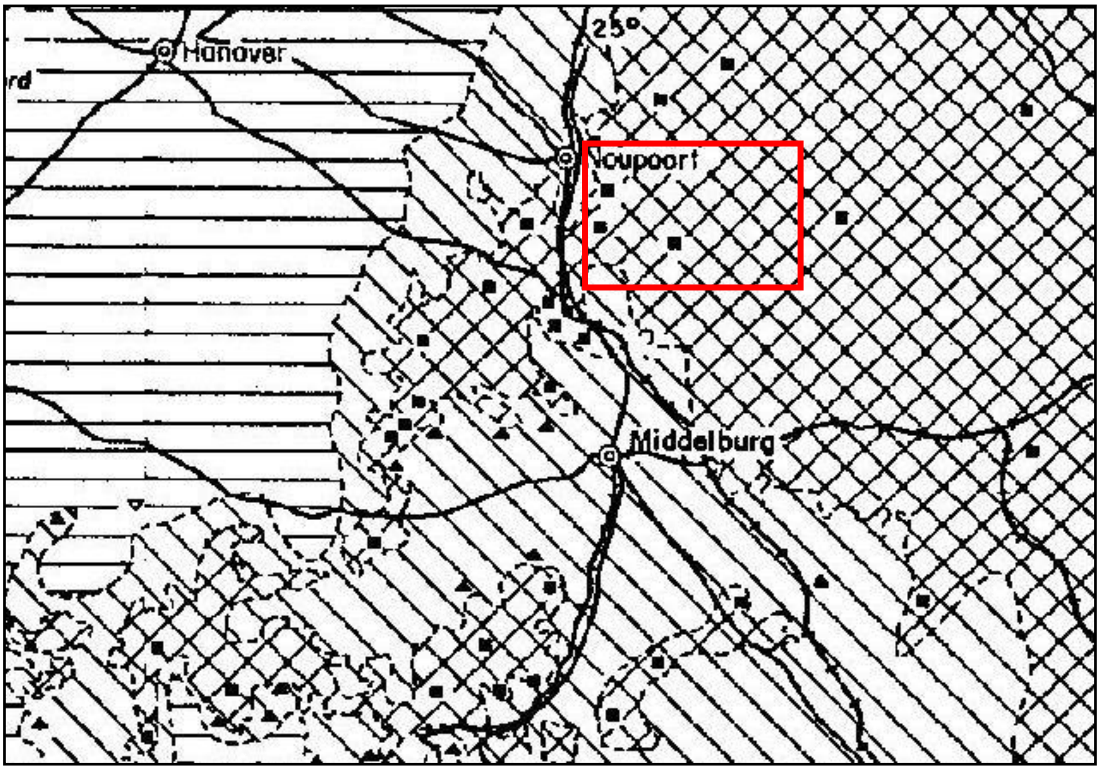

Fig. 28. Fossil zonation map of the Middelburg – Noupoort region showing the occurrence of several vertebrate fossil localities in the area to the southeast of Noupoort (red rectangle). Black squares here refer to fossils of the Early Triassic *Lystrosaurus* Assemblage Zone (mainly within the Katberg Formation). Triangles to the southwest are *Daptocephalus* (*Dicynodon*) AZ fossils within Late Permian rocks of the Adelaide Subgroup. Figure modified from Karoo biozonation map of Kitching (1977).

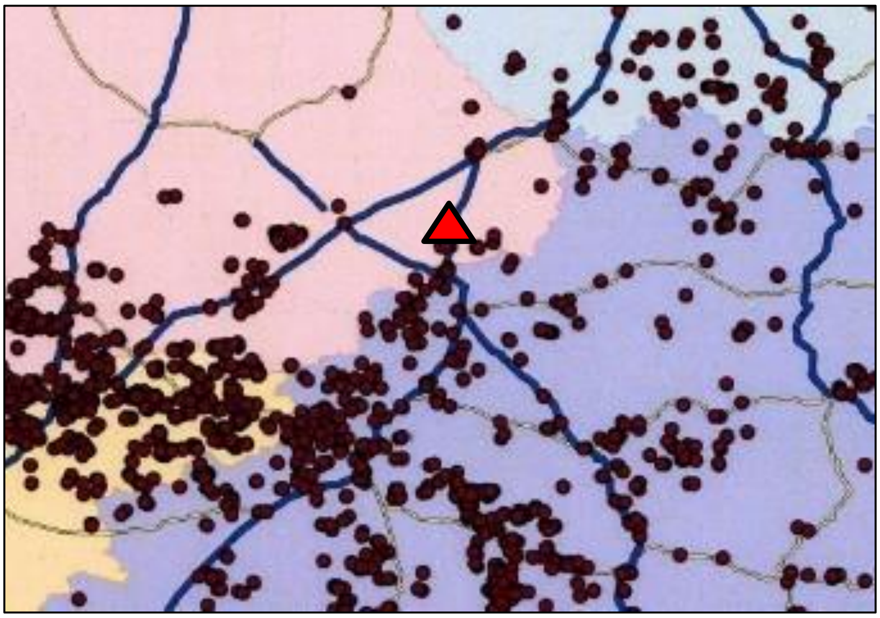

Fig. 29. Map of Beaufort Group vertebrate fossil localities in the vicinity of Noupoort (red triangle), abstracted from Nicolas (2007). Pink – N. Cape. Dark blue – Eastern Cape.

4.2. New palaeontological records in the WEF study area

No substantial, well-articulated Karoo vertebrate fossil remains were observed during the present field study of the San Kraal WEF study area near Noupoort. Since abundant and diverse vertebrate remains have been recorded from the same stratigraphic units elsewhere in the Main Karoo Basin (see refs. above), this lack of fossil finds is largely attributed to the paucity of overbank mudrock exposures that are the main locus of fossil preservation within the Permo-Triassic sedimentary bedrocks represented here. These mudrocks are only rarely seen along the escarpment areas, and almost never exposed on the sandstone plateaux where most of the WEF infrastructure will be situated (Figs. 4-6). The only vertebrate body fossils recorded here comprise a few isolated fragments of bone and teeth – most likely of therapsid affinity (and probably *Lystrosaurus* for the most part) – found embedded within calcrete nodule breccio-conglomerates that are associated with the bases of major sandstone packages of the Katberg Formation (Fig. 30 a-f, satellite images 33 & 34). These fossils represent vertebrate remains lying on the floodplain surface or already embedded within subsurface pedogenic calcrete palaeosols (fossil soils) that were re-exhumed or entrained by floods during episodes of major denudation of the arid Early Triassic landscape.

A series of indubitable to poorly-preserved and ambiguous, large vertebrate burrow casts (*c*. 30-50 cm diameter) have been recorded on the farm Winterhoek 118 close to one of the 132 kV grid connection routes for the San Kraal WEF (Locs. 119, 120, 122 and 123; see satellite maps Figs. 35 and 36). These are described and illustrated in the palaeontological report for the Phezukomoya WEF (Almond, 2017). One of the burrow casts is associated with disarticulated bones. Because of their scientific interest (Field Rating IIIB), it is recommended that the fossil burrow sites be protected by a 50 m-wide buffer zone.

Equivocal vertebrate burrows cross-cutting colour-banded overbank mudrocks are seen in the lower Katberg along Oorlogspoort (Fig. 31) but these require further study before their fossil burrow status is accepted; colouration may be deceptive, secondary (diagenetic) and unrelated to meaningful grain-size contrast. In the same area thin calcareous sandstones displaying numerous closely-spaced, vertical cyclindrical traces are now interpreted as casts of reedy plant stems rather than *Skolithos* invertebrate burrows (*cf* Almond 2012) (Fig. 32).

Apart from the Winterhoek 118 vertebrate burrows, all these fossil occurrences belong to categories that have been widely recorded within the extensive Katberg Formation outcrop area of the Main Karoo Basin and do not present obvious unique features. Their palaeontological research and conservation value is therefore assessed as LOW and they are assigned a provisional Field Rating IIIC Local Resource (Appendix 1).

The central Karoo superficial or “drift” deposits have been comparatively neglected in palaeontological terms. However, they may occasionally contain important fossil biotas, notably the bones, teeth and horn cores of mammals as well as remains of reptiles like tortoises. Other late Caenozoic fossil biotas from these superficial deposits include non-marine molluscs (bivalves, gastropods), ostrich egg shells, tortoise remains, trace fossils (*e.g.* calcretised termitaria, coprolites, invertebrate burrows), and plant material such as peats or palynomorphs (pollens) in organic-rich alluvial horizons and diatoms in pan sediments. No fossil remains were recorded from the various Late Caenozoic superficial deposits examined during the present field assessment. Occasional embedded stone artefacts are of interest in constraining their age to the Middle Pleistocene or Holocene, *i.e.* the last *c.* 300 000 years.

Fig. 30. Fragmentary vertebrate fossils recorded from calcrete nodule breccio-conglomerates within the Katberg Formation: (a) Well-exposed fossiliferous breccia on Holbrook 181 (Loc. 045) (Hammer = 27 cm). (b) Small bone fragment, 20 mm long. (c) Small bone fragment, 35 mm long. (d) Bones enclosed in pedogenic calcrete prior to reworking (arrows; scale in mm). (e) Fragment of jaw bone with tusk, 38 mm long. (f) Fragment of tooth, 10 mm long. Fossils all from Loc. 045 with exception of tooth in (f) from Loc. 056 (See satellite images 33 and 34).

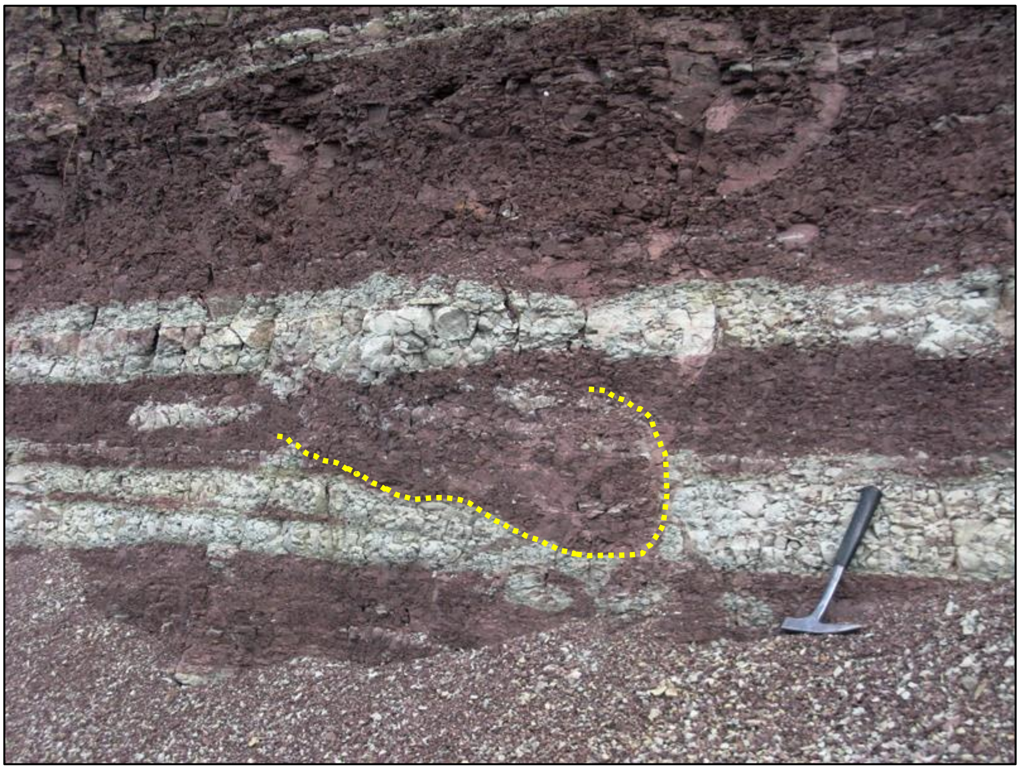

Fig. 31. Colour-banded overbank mudrocks within the lower Katberg Formation showing *equivocal,* mudrock-infilled "vertebrate burrow" (outlined), Oorlogspoort (Loc. 056) (Hammer = 27 cm).

Fig. 32. Thin calcareous sandstone with small cylindrical traces interpreted as stem casts of reedy vegetation, such as equisetalean ferns (Loc. 056) (Scale in cm).

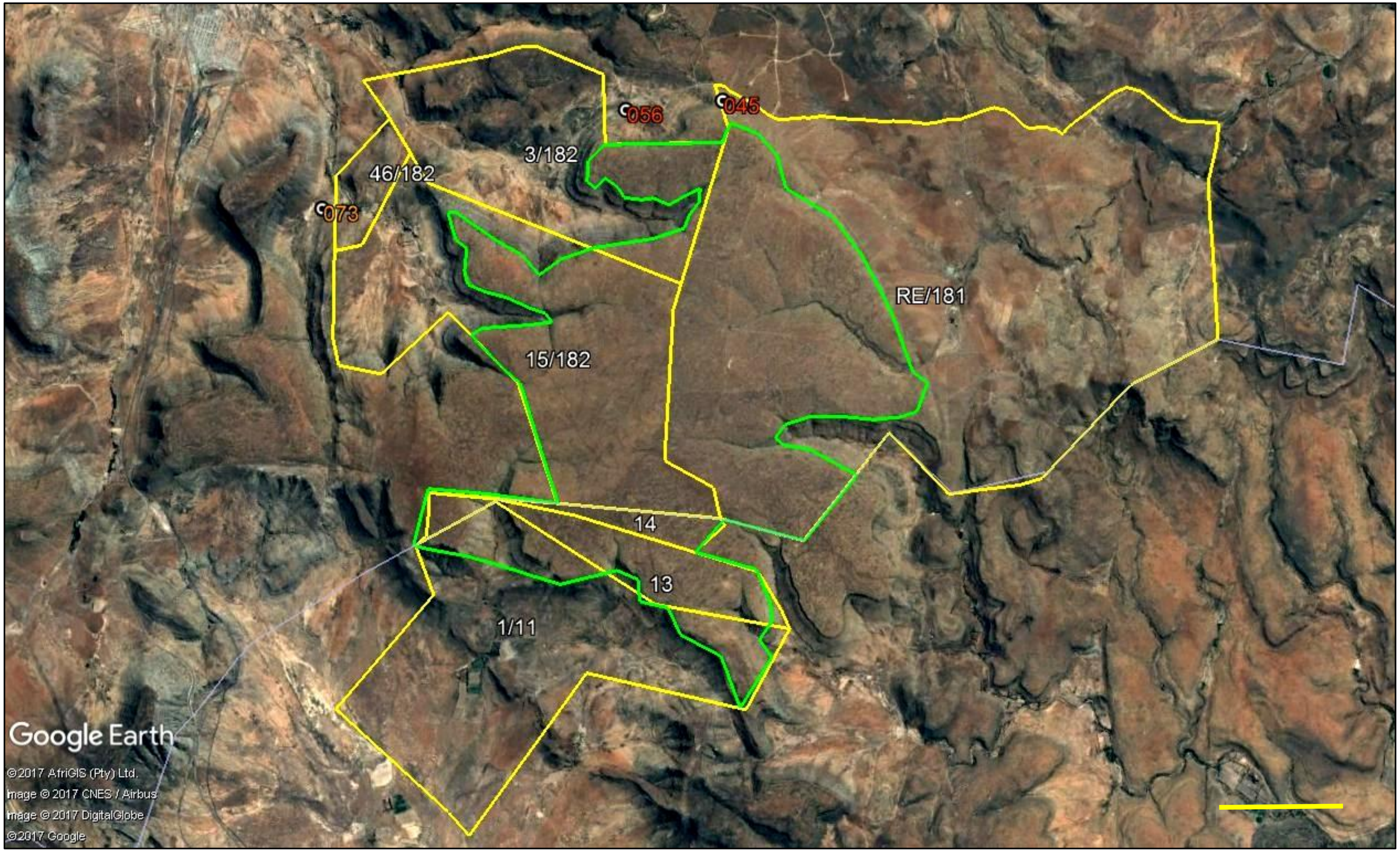

Fig. 33. Google earth© satellite image of the San Kraal WEF project area showing numbered Katberg Formation fossil localities (045, 056 in red) and good exposure of the Palingkloof Member of the Balfour Formation (073 in orange). All these sites lie outside the core WEF development area that is mainly located on the sandstone plateau (green polygon). See Appendix for locality details. Scale bar = 2 km.

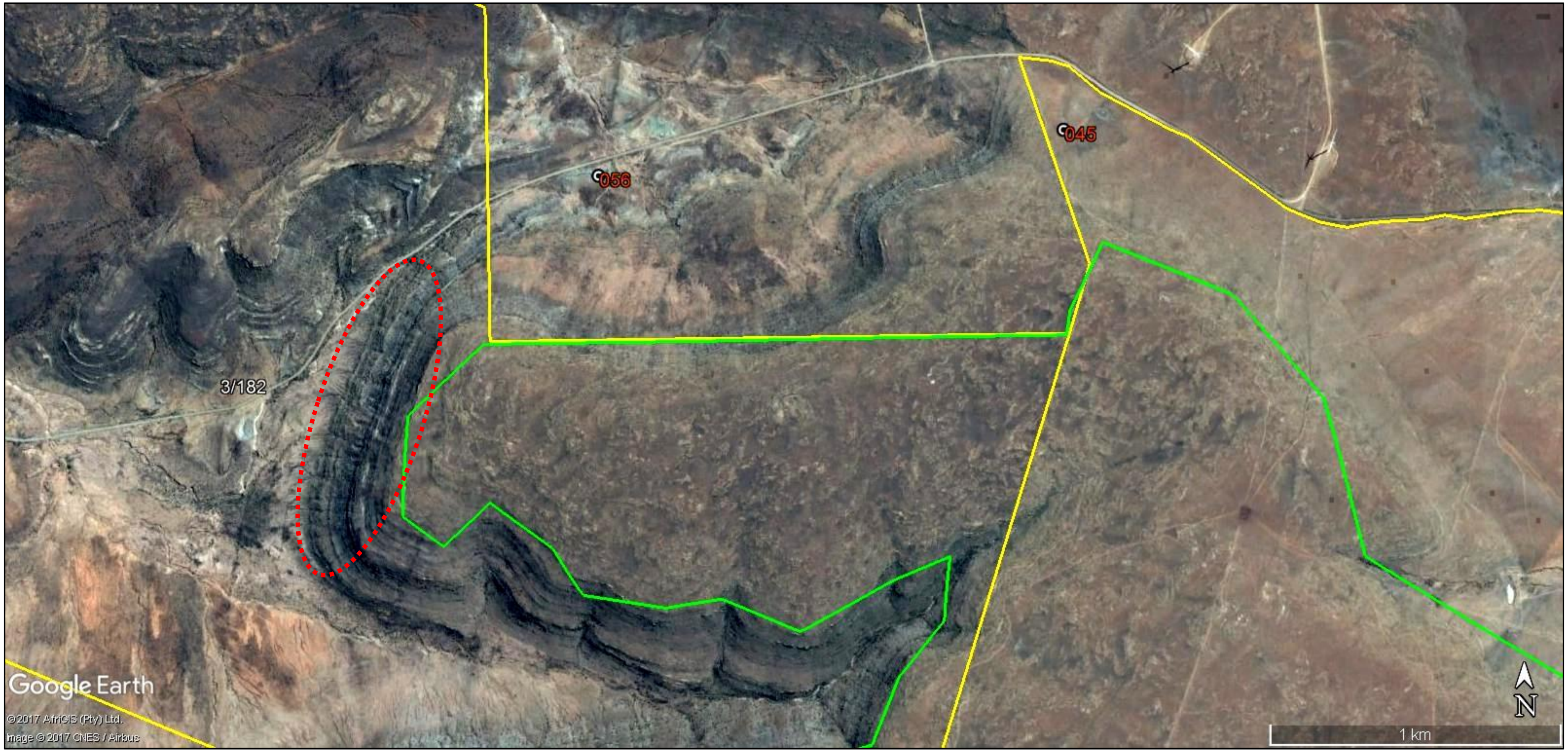

Fig. 34. Satellite image of northern sector of the San Kraal project area (yellow polygon) showing numbered vertebrate fossil localities (045, 056) within the Katberg Formation to the south of the Oorlogspoort dust road. A good escarpment section through the sharp-based Katberg Formation (Fig. 4) is present in the area outlined in red. The low-lying *vlaktes* to the west of the escarpment here are underlain by the Palingkloof Member (uppermost Balfour Formation) but mantled by thick alluvium and colluvium. Note rocky Katberg sandstone terrain on the plateau where most of the WEF infrastructure will be constructed (area outlined in green).

5. EVALUATION OF IMPACTS ON PALAEONTOLOGICAL HERITAGE

The San Kraal WEF study area is located in a region of the Great Karoo that is underlain by potentially fossiliferous sedimentary rocks of Permo-Triassic and younger, Late Tertiary or Quaternary, age (Sections 3 & 4). The construction phase of the proposed wind energy facility will entail substantial excavations into the superficial sediment cover and locally into the underlying bedrock as well. These include, for example, surface clearance and excavations for the wind turbine foundations, laydown and hardstanding areas, internal access roads, underground cables, transmission line pylon footings, electrical substations, operations and services workshop area/office building and construction camps. All these developments may adversely affect potential fossil heritage within the study area by destroying, disturbing or permanently sealing-in fossils preserved at or beneath the surface of the ground that are then no longer available for scientific research or other public good.

The inferred impact of the proposed San Kraal WEF on local fossil heritage resources – including the 132 kV grid connection - is briefly evaluated here, based on the system used by ARCUS Consulting. This assessment applies only to the construction phase of the development since further significant impacts on fossil heritage during the planning, operational and decommissioning phases of the facilities are not anticipated.

In general, the destruction, damage or disturbance out of context of fossils preserved at the ground surface or below ground that may occur during construction represents a *negative* impact that is limited to the development footprint (*local / within site boundary*). Such impacts can often be mitigated but cannot be fully rectified or reversed (*i.e. long-term, irreversible*). Most of the sedimentary formations represented within the study area contain fossils of some sort. The pervasive mantle of alluvium, scree and soil covering the vast majority of the potentially-fossiliferous overbank mudrocks within the WEF study area - including the sandstone plateau areas where most of the infrastructure will be situated – is almost certainly largely responsible for the lack of significant fossil finds here during the present field study. Fossils may be expected in the subsurface and negative impacts at some level on fossil heritage are therefore considered *certain*.

Most fossil occurrences represent taxa that probably occur widely within the study region (*i.e. not unique / irreplaceable*). However, occasional exceptional, scientifically-valuable fossils - such as well-preserved, well-articulated vertebrate skeletons as well as vertebrate burrows - have been recorded in the broader study region around Noupoort. Furthermore, the Beaufort Group bedrock succession underlying the WEF project area records major palaeoecological and evolutionary events across the Permo-Triassic boundary (catastrophic mass extinction event) which are an important focus of ongoing academic studies in Karoo palaeontology. The severity / intensity of anticipated impacts on palaeontological heritage before mitigation is assessed as *moderate (negative)*, given the predicted occurrence of sparse but scientifically-valuable (and potentially *irreplaceable*) fossils in the subsurface within the development footprint. Due to the low extent, moderate severity and permanent duration of potential impacts, the impact significance of the proposed WEF is assessed as *medium (negative)* before mitigation. Confidence levels in this assessment are *medium*, given (1) the extensive palaeontological literature on the Karoo bedrocks concerned weighed against (2) very low levels of bedrock exposure within the study area and (3) the unpredictable distribution of well-preserved fossils in the subsurface.

It should be noted that, should the recommended mitigation measures for the construction phase of the WEF development, as outlined in Section 6 of this report, be consistently followed-though, the impact significance would remain *medium* (*negative*) but would entail both positive and negative impacts. Residual negative impacts from inevitable loss of some valuable fossil heritage would be partially offset by an improved palaeontological database for the study region as a direct result of appropriate mitigation. This is a *positive* outcome because any new, well-recorded and suitably-curated fossil material from this palaeontologically little-known region would constitute a useful addition to our scientific understanding of Karoo Basin fossil heritage.

There are no fatal flaws in the proposed WEF project from a palaeontological heritage viewpoint and no objects to authorisation of the development, provided that the recommended mitigation measures are fully implemented.

5.1. Power line connection to the national grid

The San Kraal WEF will be connected to the National Grid *via* a *c*. 25 km-long 132 kV high voltage overhead power line from the on-site switching station to the proposed Umsobomvu substation situated some 23 km southwest of Noupoort (Fig. 35). A preferred powerline route option together with two alternative routes, Alternatives 1 and 2, are briefly assessed here based on palaeontological field experience of the region (adjoining Umsobomvu, San Kraal and Phezukomoya WEF field study areas) as well as recent field examination of short sectors of the powerline corridors.

All three route options traverse similar geological terrain underlain by Beaufort Group bedrocks with occasional elongate, steeply-dipping dolerite intrusions (See geological map, Fig. 2). Apart from the thicker channel sandstones, the Karoo bedrocks are rarely exposed and in low-lying areas are mantled by several meters of, at most, very sparsely-fossiliferous alluvial deposits, such as exposed in areas of deep *donga* erosion and along incised stream beds. With all three power line route options, direct impacts on surface or subsurface fossils as a result of the powerline construction (notably pylon footings, clearance for new access roads) are likely to be similar and minor (low impact significance), especially given the short length of the power line. The proposed sites for the on-site substation, switching station and connecting overhead powerline on the Katberg sandstone plateau within the main WEF project area are unproblematic from a palaeontological view (low impact significance).

As shown in Figure 36, the south-western sector of the powerline Alternative 1 passes close to an extensive stream bed exposure of Katberg Formation bedrocks which contain a scientifically interesting assemblage of large fossil vertebrate burrows, at least one of which is associated with disarticulated bones, possibly of the trace-maker itself (These occurrences are illustrated and described in the separate palaeontological report for the Phezukomoya WEF, Almond 2017). It is recommended that these fossil sites are protected by a 50 m-wide buffer zone (yellow shape) which would then be transgressed by the Alternative 1 powerline route. This is accordingly the least preferred route option on palaeontological heritage grounds. There is no preference between the currently preferred route and the Alternative 2 route. Should the Alternative 1 route be chosen on other grounds, it is recommended that the sector passing close to the fossil sites be moved south-eastwards to run at least 25 m from the stream bed where the fossil vertebrate burrows are exposed.

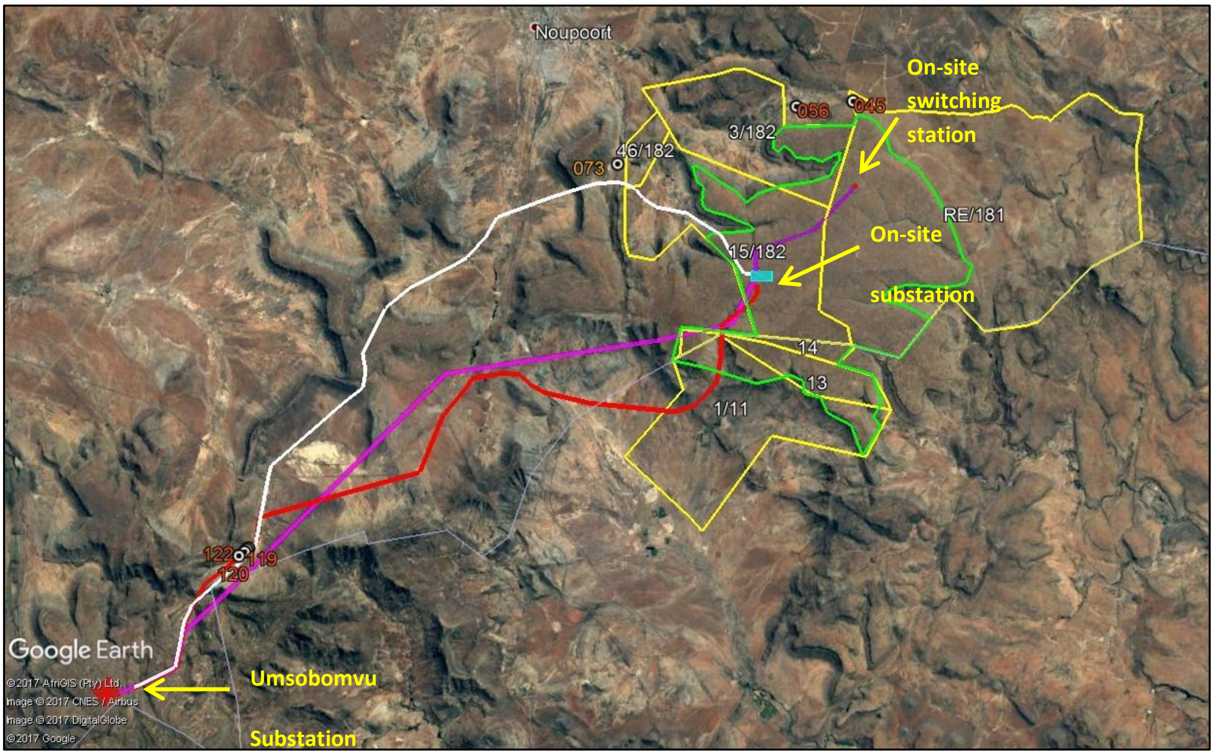

Fig. 35. Google Earth satellite image showing the preferred 132 kV power line connection between the San Kraal WEF and the Umsobomvu substation (purple line) as well as two other route options: Alternative 1 (red line) and Alternative 2 (white line).

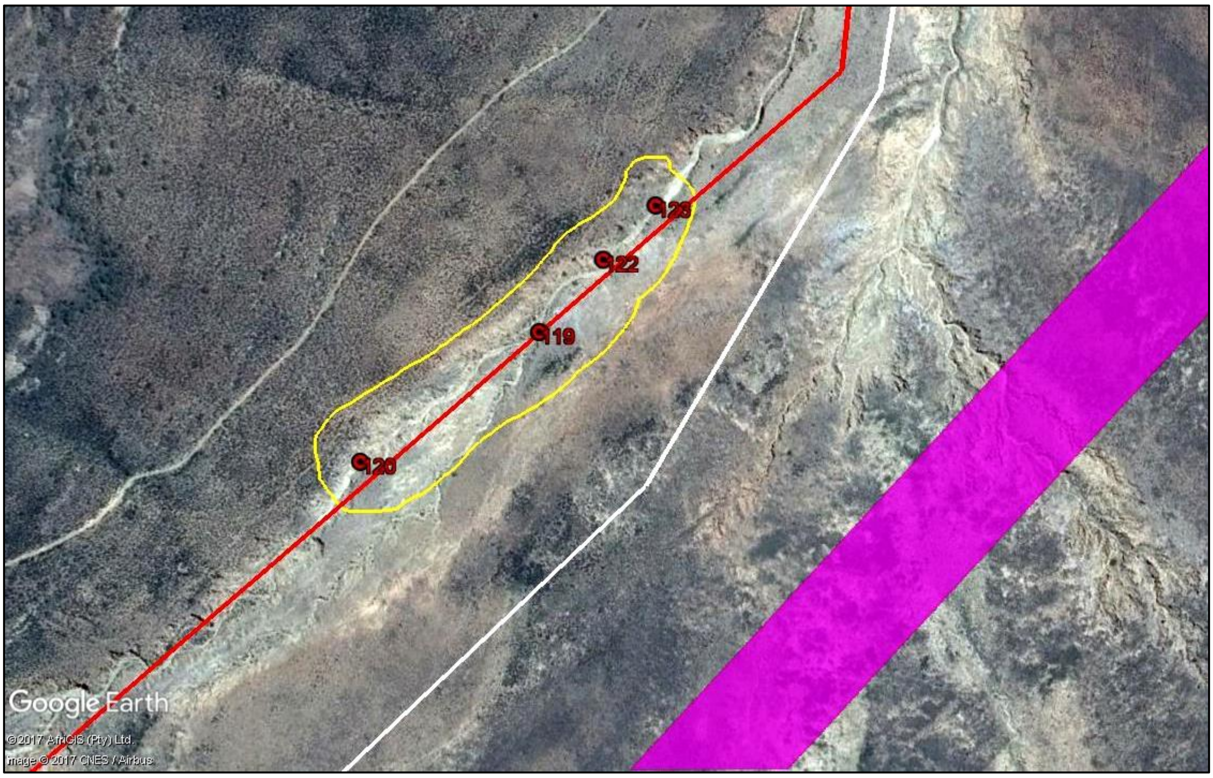

Fig. 36. Detail of the south-western sectors of the 132 kV powerline routes shown in the previous figure. Alternative 1 (red line) passes through the proposed 50 m-radius protective buffer (yellow shape) surrounding several important fossil vertebrate burrow sites in the Katberg Formation that are exposed in a deeply-incised stream bed (Locs. 119-123). Alternative 2 route option – white. Preferred route option – purple.

5.2. Cumulative impact assessment

Previous palaeontological assessments (PIAs) for several proposed or authorized alternative energy projects within a 35 km radius of the San Kraal WEF project area have been briefly reviewed (Note that heritage assessments for some projects have been accepted without a PIA; *e.g.* Dida Solar Energy Facility on the farm Rietfontein north of Noupoort). These include field-based assessments for the Noupoort WEF (Almond 2012), the Umsobomvu WEF (Almond 2015), the Phezukomoya WEF (Almond 2017) as well as several solar projects near Noupoort and Middelburg (Gess 2012a, 2012b, Butler 2016).

In the author's opinion:

- Palaeontological impact significances inferred for these projects that range from low (Noupoort and Umsobomvu WEFs) to medium (San Kraal and Phezukomoya, Naauwpoort 1 solar project) to unassessed reflect different assessment approaches rather than contrasting palaeontological sensitivities and impact levels;

- Meaningful cumulative impact assessments require comprehensive data on *all* major developments within a region, not just those involving alternative energy, as well as an understanding of the extent to which recommended mitigation measures are followed through;

- Trying to assess cumulative impacts on fossil assemblages from different stratigraphic units (in this case, Late Permian fossils from the Adelaide Subgroup and Early Triassic assemblages from the Tarkastad Subgroup) has limited value.

Given the comparatively small combined footprint of the alternative energy projects under consideration compared with the very extensive outcrop areas of the Balfour and Katberg Formations, the cumulative impact significance of the San Kraal WEF is assessed as LOW.

6. RECOMMENDATIONS FOR MONITORING AND MITIGATION

Given (1) the significant potential for scientifically-valuable fossils being disturbed, damaged or destroyed during the construction phase of the WEF as well as (2) the high level of uncertainty regarding fossil distribution in the subsurface, a precautionary approach to palaeontological mitigation is considered appropriate here. Following discussions with SAHRA (Dr Ragna Redelstorff, Oct. 2017), it is therefore proposed that initially a representative sample (*c*. 10%) of excavations for wind turbine footings be monitored by a professional palaeontologist during the early construction phase. The monitoring protocol should be developed by the palaeontologist appointed in consultation with the developer and SAHRA so as to maximise the palaeontological outcome without interfering unduly with the construction program. On completion of this initial phase of monitoring, a Phase 2 palaeontological report, with any recommendations for further specialist monitoring or mitigation, should be submitted by the palaeontologist to SAHRA for comment. This stepwise approach is recommended because it may well prove impracticable to recognise record and sample useful fossil material from turbine excavations due to factors such as excessive fragmentation of the bedrock and fossils, obscuring of freshly-excavated bedrock by soil or dust, or safety considerations.

No palaeontological No-Go areas or fossil sites requiring mitigation have been identified within the main WEF development footprint on the Katberg sandstone plateau. In the grid connection study area several vertebrate burrows exposed in a stream bed on Farm Winterhoek 118 close to 132 kV power line route Alternative 1 (Fig. 36) should be protected by a 50m-radius buffer zone. Should the Alternative 1 route rather than the currently preferred route be finally chosen, it is recommended that that sector passing close to the fossil sites be moved south-eastwards to run at least 25 m from the stream bed.

In addition to the specialist palaeontological monitoring outlined above, the ECO responsible for the construction phase of the project should be aware of the potential for important fossil finds and the necessity to conserve them for possible professional mitigation (See, for example, Macrae 1999 for a well-illustrated popular account of Karoo fossils). The ECO should monitor all substantial excavations into sedimentary rocks for fossil remains on an on-going basis during the construction phase.

Recommended mitigation of chance fossil finds during the construction phase of the WEF and associated grid connection involves safeguarding of the fossils (preferably *in situ*) by the responsible ECO and reporting of finds to SAHRA for the Northern Cape (Contact details: SAHRA, 111 Harrington Street, Cape Town. PO Box 4637, Cape Town 8000, South Africa. Phone: +27 (0)21 462 4502. Fax: +27 (0)21 462 4509. Web: www.sahra.org.za) and to ECPHRA for the Eastern Cape (ECPHRA contact details: Mr Sello Mokhanya, 74 Alexander Road, King Williams Town 5600; Email: smokhanya@ecphra.org.za). Where appropriate, judicious sampling and recording of fossil material and associated geological data by a qualified palaeontologist may be required by the relevant heritage regulatory authorities. Any fossil material collected should be curated within an approved repository (museum / university fossil collection) by a qualified palaeontologist. These recommendations should be included within the Environmental Management Programme for the proposed alternative energy project.

Given the internationally recognised value of Karoo fossil heritage (*e.g.* Macrae 1999, McCarthy & Rubidge 2005, Choiniere & Rubidge 2016), the known occurrence of scientifically-valuable fossil material in the Noupoort region, as well as the legal protection of all fossil remains under the National Heritage Resources Act (1999), these mitigation measures are considered to be essential.

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9. QUALIFICATIONS & EXPERIENCE OF THE AUTHOR

Dr John Almond has an Honours Degree in Natural Sciences (Zoology) as well as a PhD in Palaeontology from the University of Cambridge, UK. He has been awarded post-doctoral research fellowships at Cambridge University and in Germany, and has carried out palaeontological research in Europe, North America, the Middle East as well as North and South Africa. For eight years he was a scientific officer (palaeontologist) for the Geological Survey / Council for Geoscience in the RSA. His current palaeontological research focuses on fossil record of the Precambrian - Cambrian boundary and the Cape Supergroup of South Africa. He has recently written palaeontological reviews for several 1: 250 000 geological maps published by the Council for Geoscience and has contributed educational material on fossils and evolution for new school textbooks in the RSA.

Since 2002 Dr Almond has also carried out palaeontological impact assessments for developments and conservation areas in the Western, Eastern and Northern Cape, Mpumalanga, Free State, Limpopo, Northwest and Kwazulu-Natal under the aegis of his Cape Town-based company *Natura Viva* cc. He has been a long-standing member of the Archaeology, Palaeontology and Meteorites Committee for Heritage Western Cape (HWC) and an advisor on palaeontological conservation and management issues for the Palaeontological Society of South Africa (PSSA), HWC and SAHRA. He is currently compiling technical reports on the provincial palaeontological heritage of Western, Northern and Eastern Cape for SAHRA and HWC. Dr Almond is an accredited member of PSSA and APHP (Association of Professional Heritage Practitioners – Western Cape).

Declaration of Independence

I, John E. Almond, declare that I am an independent consultant and have no business, financial, personal or other interest in the proposed development project, application or appeal in respect of which I was appointed other than fair remuneration for work performed in connection with the activity, application or appeal. There are no circumstances that compromise the objectivity of my performing such work.

Dr John E. Almond.
Palaeontologist,
***Natura Viva* cc**

APPENDIX: GPS LOCALITY DATA

All GPS readings were taken in the field using a hand-held Garmin GPSmap 60CSx instrument. The datum used is WGS 84.

Loc. No.	GPS DATA	COMMENTS
023	S31° 12' 43.4" E25° 00' 54.6"	Hartebeest Hoek 182. Good views of Katberg Fm succession on southern side of Oorlogspoort dust road. Lower part of succession with well-spaced, prominent-weathering, laterally-extensive, tabular, grey-green to pale brownish-weathering sandstones, with intervening thick mudrock packages largely obscured by sandstone scree. Closely-spaced to amalgamated channel sandstones towards top of Katberg succession form cliff around rim of plateau.
024	S31° 13' 50.6" E24° 59' 14.2"	Hartebeest Hoek 182. Alluvial-mantled *vlaktes* south of Hartebeest Hoek homestead. Views of Katberg escarpment.
025	S31° 14' 07.7" E24° 59' 28.4"	Hartebeest Hoek 182. Thick prism or apron of Late Caenozoic mixed colluvial, alluvial and sheetwash deposits along foot of Katberg escarpment. Gently-sloping, laterally-coalescent alluvial (piedmont) fans centred on stream gullies down escarpment. Poorly-sorted, semi-consolidated sandy and gravelly sediments exposed by donga erosion beneath mantle of rubbly, downwasted surface gravels of platy to blocky sandstone (majority), dolerite corestones, diagenetic calcareous concretions. Some clasts secondarily ferruginised / impregnated with manganese minerals.
026	S31° 12' 53.7" E24° 59' 10.9"	Hartebeest Hoek 182. Steep dolerite dyke with rubbly corestone-strewn surface in nek between Goedehoop and Hartebeest Hoek homesteads. Late Caenozoic calcrete development in superficial deposits in vicinity of dolerite (*e.g.* in farm tracks).
027	S31° 16' 52.3" E25° 01' 35.4"	Tweefontein 1/11 / Beskuitfontein. Views of west-facing steep Katberg escarpment cut by occasional steep, thick dolerite dykes (route of most tracks up to Katberg plateau). Almost no mudrock exposure of Lower Beaufort Group in escarpment or *vlaktes*.
028	S31° 17' 16.7" E25° 02' 13.2"	Tweefontein 1/11 / Beskuitfontein. Stream bed exposures of Lower Beaufort Group (probably upper Adelaide Subgroup) bedrocks – yellowish-green channel sandstones overlain by c. 2.5 m of alluvium including thin basal alluvial sandstone gravels and then well-sorted brownish sandy alluvium.
029	S31° 17' 16.2" E25° 02' 09.6"	Tweefontein 1/11 / Beskuitfontein. Extensive stream bed exposures of Lower Beaufort Group (probably Katberg Fm) bedrocks overlain by coarse rubbly alluvial gravels and finer, thick-bedded sandy alluvium with gravel lenticles. Yellowish-brown channel and crevasse-splay sandstones with thin (to 20 cm) lenticular mudflake breccio-conglomerates interbedded with thin-bedded grey-green overbank siltstones. Sharp basal sandstone contacts. Irregular rounded, pale creamy-coloured siliceous nodules and vugs are probably a consequence of nearby dolerite intrusion. Bedding planes with current ripple marks.
030	S31° 17' 34.7" E25° 02' 37.8"	Tweefontein 1/11 / Beskuitfontein. Nek in pass up to Katberg plateau. Views of Katberg escarpment showing thick, amalgamated channel sandstone package towards top of succession. Hillslope exposure of thin-bedded, tabular, purple-brown and blue-green overbank siltstone package with horizon of large, rusty-brown pedogenic calcrete concretions just below finely-gravelly, rusty-brown calcrete breccio-conglomerate horizon. Probably a finer-grained package within the Katberg Formation but with some facies resemblance to Palingkloof Member of Adelaide Subgroup. Overlying thick-bedded tabular channel sandstone with erosional base is Katberg-like.
031	S31° 17' 33.1" E25° 02' 41.4"	Tweefontein 1/11 / Beskuitfontein. Hillslope and farm track exposure through thick (several m) massive to thin-bedded, purple-brown overbank mudrocks. Overlying cross-bedded channel sandstone with well-developed (*c*. 1.5 to 2m thick), grey, massive to vaguely horizontally-bedded basal calcrete breccio-conglomerate – mainly composed of rounded to subangular reworked pedogenic calcrete clasts up to a few cm diameter. No reworked bone fragments seen.
032	S31° 17' 29.0" E25° 02' [illegible]	Tweefontein 1/11 / Beskuitfontein. Farm track exposure of thick, massive, purple-brown overbank mudrock package. Mudrocks weathered near surface.
033	S31° 16' 51.5"	Tweefontein 1/11 / Beskuitfontein. Prominent-weathering kranz of massive,

	E25° 02' 31.1"	thick-bedded, horizontal- to low-angle cross-bedded, Katberg channel sandstones on plateau. Karstic weathering features (*e.g.* polygonal solution cracks or tessellation / alligator cracking, case hardening). Downwasted sandstone surface gravels, some ferruginised, and orange-brown sandy soils.
034	S31° 16' 54.9" E25° 02' 31.2"	Tweefontein 1/11 / Beskuitfontein. Good examples of large-scale tabular to trough cross-bedding within Katberg channel sandstones.
036	S31° 16' 40.6" E25° 02' 23.9"	Tweefontein 1/11 / Beskuitfontein. Katberg tabular channel sandstones showing extensive good examples of complex etched surfaces due to lichen weathering (cf Grab *et al.* 2011). These features occur widely on the Katberg sandstone plateau areas, especially on damper south-facing slopes. Karstic weathering features also well seen here, including "rock doughnuts" with raised annular rim surrounding a central steep-edged depression, and other forms of rock basins (*ibid.*).
037	S31° 16' 27.4" E25° 02' 43.7"	Farm RE13. Artificial "adit" into thick, dark grey, sandy carbonaceous upper soils on hillslope besides dam. Underlying sandy subsoil with well-developed stone line grade down into weathered mudrock saprolite and fresher hackly-weathering grey-green and purple-brown siltstone.
038	S31° 16' 13.9" E25° 02' 17.0"	Farm RE14. Quarry site for joint blocks of Katberg sandstone used as fence poles etc. Circular solution hollows in sandstone nearby.
039	S31° 16' 04.8" E25° 01' 44.0"	Farm RE14. Good horizontal bedding within Katberg sandstones at top of kloof.
040	S31° 15' 52.9" E25° 00' 25.7"	Farm RE14. Viewpoint across deep kloof at Katberg escarpment. Flat-bedded to gently-dipping Katberg succession with no exposure of mudrock intervals.
041	S31° 16' 28.7" E25° 01' 19.7"	Farm RE13 (western tip).Sphaeroidal carbonate concretions within massive sandstones locally abundant.
042	S31° 16' 43.8" E25° 01' 15.8"	Tweefontein 1/11 / Beskuitfontein. Exposure of Katberg grey-green overbank mudrocks with deformed sandstone lenses (perhaps burrow casts).
043	S31° 12' 13.5" E25° 02' 38.6"	Holbrook 181. Bedding plane exposures of ferruginised mudflake intraclast breccio-conglomerates capped by sandstone within Katberg Fm.
044	S31° 12' 12.8" E25° 02' 40.6"	Holbrook 181. Extensive exposure of major (up to *c*. 3 m thick), grey to greenish-blue, medium to thick-bedded, clast-supported, pebbly calcrete breccio-conglomerate composed of reworked, predominantly well-rounded pedogenic calcrete clasts in a calcareous sandy matrix. Some elongate or platy clasts. Sharply overlain by thin-bedded sandstone and cut by occasional thin (dm) dolerite dykes.
045	S31° 12' 14.2" E25° 02' 40.9"	Holbrook 181. Same calcrete conglomerate bed as above. Sparse fragmentary bone and tusk fragments among calcrete clasts, as well occasional bones embedded within reworked calcrete concretions. Field Rating IIIC Local Resource
046	S31° 12' 50.8" E25° 02' 41.7"	Holbrook 181. Good example of lichen-weathered surfaces on Katberg sandstones.
047	S31° 13' 22.0" E25° 02' 27.0"	Holbrook 181. Karstified, jointed bedding plane exposures of Katberg sandstone showing alligator tessellation, case hardening, solution hollows *etc*. Large-scale trough cross-bedding (palaeocurrents towards the N).
048	S31° 13' 30.1" E25° 02' 24.2"	Holbrook 181. Large-scale sinuous tabular and trough cross-sets within Katberg sandstone (main palaeocurrents towards the S).
049	S31° 15' 55.4" E25° 02' 41.3"	Holbrook 181. Gulley wall exposures of thick (> 3 m) pale brown sandy alluvium with thin, fine-grained gravel lenses, occasional dispersed sandstone blocks, in shallow perched stream valley near escarpment edge , capped by dark brown carbonaceous soils and then modern orange-brown sandy soils.
050	S31° 16' 01.2" E25° 03' 12.0"	Holbrook 181 Erosion gulley exposures of dark, carbonaceous soils in shallow stream valley. Contain small-scale meniscate bioturbation fabrics perhaps attributable to termites or other invertebrates.
051	S31° 15' 38.1" E25° 03' 55.8"	Holbrook 181.Viewpoint eastwards of deeply-incised Katberg escarpment with steeply-dipping dolerite intrusion cutting through tabular channel

		sandstones.
052	S31° 15' 21.9" E25° 03' 26.1"	Holbrook 181. Viewpoint into deeply-incised kloof with only occasional small exposures of purple-brown mudrock facies. Most of escarpment slopes mantled by sandstone scree and soil.
053	S31° 14' 58.8" E25° 02' 07.0"	Holbrook 181. Karstified Katberg sandstone bedding planes, alligator tessellation, solution hollows, lichen-etched surfaces.
054	S31° 13' 46.0" E25° 03' 07.3"	Holbrook 181. View across Katberg sandstone plateau with no mudrock exposure, scattered low sandstone ridges.
055	S31° 12' 47.4" E25° 03' 09.9"	Holbrook 181. Karstic (*e.g.* small mushroom pedestals / chicken heads) and lichen weathering patterns in locally well-jointed Katberg sandstone exposures.
056	S31° 12' 18.8" E25° 01' 40.2"	Hartebeest Hoek 182 (on southern side of Oorlogspoort dust road, just outside project area). Elongate borrow pit exposure into horizontal, thin-bedded purple-brown and grey-green mudrocks and thin, fine-grained sandstones of the lower Katberg Formation (with some facies resemblances to the Palingkloof Member, Balfour Formation, Adelaide Subgroup). Occasional flat-topped sandstone lenses and thin-bedded, more heterolithic packages, locally with sand-infilled desiccation cracks. Colour banding secondary, at least in part. Overlying channel sandstone fairly flat but with locally gullied base. *Possible* but equivocal vertebrate burrow cast by siltstone (requires confirmation). Float blocks of thin-bedded sandstone containing dense assemblages of cyclindrical, vertical,sand-infilled casts – probably of reedy plan stems (*e.g.* equisetaleans). Towards base of exposed succession is thin (few cm), prominent-weathering bed of ferruginised, fine-grained calcrete breccia with rare tooth fragments Some of calcrete bodies are elongate, vermiform and may be calcretised rhizoliths. Field Rating IIIC Local Resource
057	S31° 12' 24.9" E25° 01' 25.7"	Hartebeest Hoek 3/182. Lower escarpment slopes on south side of Oorlogspoort dust road. Prominent-weathering tabular channel sandstones intercalated with thick purple-brown to grey-green mudrock packages as seen in previous locality (but here mostly obscured by sandstone scree).Base of exposed succession is major pale brown channel sandstone seen in stream bed and banks besides road, also assigned to Katberg Fm. Mudrock packages show well-developed sand-infilled polygonal desiccation cracks, horizons of sphaeroidal to irregular, rusty-brown pedogenic calcrete nodules, becoming more heterolithic with thin sandstone interbeds towards top. Base of channel sandstones sharp, flat to often gullied on a small scale, associated with thick (up to 0.5 m) coarse reworked mudclast and ferruginous calcrete breccias (occasionally cross-bedded), fluted sandstone soles, lenticular, pale grey calcrete breccio-conglomerates (*e.g.* infilling gulley bases). Sandstones massive to horizontally- and thin-bedded or low angle cross-bedded.
058	S31° 13' 37.8" E24° 58' 32.8"	Hartebeest Hoek 182. Good hillslope kranz exposures of well-bedded, tough, locally vuggy, baked, thin- to medium-bedded Katberg mudrocks that here have been metamorphosed to brownish-weathering hornfels within the thermal aureole of large dolerite dyke.
059	S31° 13' 38.6" E24° 58' 31.5"	Hartebeest Hoek 182. Columnar-jointed dolerite. Rafts of bedded Katberg sediment enclosed within the dolerite intrusion represent large xenoliths of pale grey metaquartzite and darker grey hornfels. Abundant dark grey flaked hornfels stone artefacts in the vicinity and possible evidence for Stone Age quarrying.
060	S31° 13' 39.9" E24° 58' 30.2"	Hartebeest Hoek 182. Contacts between thermally metamorphosed Katberg country rocks and intrusive dolerite.
061	S31° 13' 38.9" E24° 58' 34.0"	Hartebeest Hoek 182. Surface gravels dominated by angular blocks of pale brownish-grey quartzite (some flaked).
062	S31° 14' 31.4" E24° 58' 33.3"	Hartebeest Hoek 182. Extensive bedding plane and vertical sections through a well-jointed, thick, brownish-weathering, partially-ferruginised and baked calcrete basal breccia within the Katberg Fm, forming base of major sandstone package. Composite several m-thick section with interbedded horizons and lenses of breccia (fine- and coarse-grained calcrete gravels

		and mudrock intraclasts) and sandstone. Upper surface of bed shows karstified polygonal crack pattern.
063	S31° 15' 19.9" E25° 00' 08.9"	Hartebeest Hoek 182. Katberg plateau with extensive kartsified sandstone bedding surfaces – polygonal alligator cracking, steep-walled subrounded solution hollows (rock basins / gnammas), plus lichen weathering features on some joint blocks but not others (clearly post-dated karstificiation and case-hardening).
064	S31° 15' 04.5" E25° 00' 22.1"	Hartebeest Hoek 182. Katberg sandstone exposures showing trough cross-bedding. Downwasted rubbly, agular sandstone gravels overlying rocky areas. Lichen weathering.
067	S31° 15' 04.4" E24° 58' 56.6"	Hartebeest Hoek 182. Good examples of lichen weathering with living lichens *in situ*. Viewpoint towards west across eastern portion of Phezukomoya project area – dissected upland plateau area with occasional exposures of Katberg channel sandstone but not of intervening mudrocks.
068	S31° 14' 29.5" E24° 58' 34.0"	Hartebeest Hoek 182. Stream bed exposure of brownish-weathering, cross-laminated basal calcrete breccia sharply capped by sandstone, as well as mudflake breccias. Overhang of thick-bedded Katberg channel sandstone.
069	S31° 14' 29.9" E24° 58' 36.1"	Hartebeest Hoek 182. Extensive hillslope exposures of cross-bedded, ferruginised, finely gravelly calcrete basal breccia (several m thick). No sign of fossil bone observed. Sharply capped by thick channel sandstone package.
070	S31° 14' 29.7" E24° 58' 37.6"	Hartebeest Hoek 182. Base of thick Katberg cross-bedded channel sandstone package overlying *c*. 1m-thick coarse basal mudrock breccias – laterally equivalent to the thick calcrete basal breccias observed just to the west (Phezukomoya project area); *i.e.* calcrete breccias are lenticular in geometry.
071	S31° 13' 42.7" E24° 58' 30.5"	Hartebeest Hoek 182. Low (sev m) kranz of well-bedded, thermally-metamorphosed quartzite and hornfels within dolerite thermal aureole. Angular quartzitic surface rubble.
072	S31° 13' 10.4" E24° 58' 32.6"	Hartebeest Hoek 182. Extensive gently-sloping hillslope exposures of hackly-weathering purple-brown and grey-green overbank mudrocks – probably upper part of thick latest Permian Palingkloof Member mudrock package (Balfour Fm, Adelaide Subgroup). Horizons of brownish pedogenic calcrete concretions, very thin to thin grey-green crevasse-splay sandstones (heterolithic tops of few m-thick upward-coarsening packages), isolated lenticular sandstone bodies (gully infills or possibly vertebrate burrows – highly equivical), patches of small-scale wave ripples (playa ponds). Field Rating IIIC Local Resource
073	S31° 13' 10.7" E24° 58' 27.7"	Hartebeest Hoek 182. Excellent stream gulley exposures of lower part of Palingkloof Member succession showing colour-banded mudrocks and fine, thin-bedded sandstones in vertical profile. Shallow erosional cut-and-fill structures picked out by colour banding. Packages of massive mudrocks passing up into thinly-interbedded sandstone and siltstone couplets. Occasional prominent-weathering thin sandstones (probable crevasse splays) and brownish-weathering palaeocalcrete lenses within coarser grey-green tops of cycles. No large brown pedocrete nodules seen.
074	S31° 12' 35.6" E24° 58' 31.0"	Hartebeest Hoek 182. Extensive area of erosion-gullied, thick alluvial deposits north of farm dam wall. Several m-thick succession of well-bedded, occasionally laminated, brown sandy alluvium with occasional poorly-sorted gravel lenses and horizons. Downwasted coarser gravels at surface.
119	S31° 19' 08.0" E24° 51' 46.3"	Winterhoek 118. Stream bed exposure of pale buff Katberg Fm sandstones and grey-green overbank mudrocks showing several well-preserved, gently- to quite steeply-sloping, subcylindrical sandstone casts of vertebrate burrows (*c*. 30 cm wide) (See Almond 2017). Proposed Field Rating 111B Local Resource. 50 m-radius buffer zone recommended. Katberg Fm bedrocks are overlain here by thick alluvial succession with coarse gravels at base, brown sandy alluvium above and pale grey modern alluvium at the top.
120	S31° 19' 11.5"	Winterhoek 118. Stream bed exposure of baked Katberg Fm channel or

	E24° 51' 40.3"	thick crevasse-splay sandstone with probable baked sandstone casts of subhorizontal large (30-40 cm wide) vertebrate burrows exposed on the upper surface (See Almond 2017). Proposed Field Rating 111B Local Resource. 50 m-radius buffer zone recommended.
122	S31° 19' 06.0" E24° 51' 48.5"	Winterhoek 118. Stream bed exposure of hackly, grey-green Katberg overbank mudrocks with several probable sandstone casts of large vertebrate burrows (up to 60 cm diameter, compressed ellipsoidal cross-section) – perhaps a warren. Occasional small-scale (1 cm –diam.) *Katbergia* scratch burrows in area (See Almond 2017).. Proposed Field Rating 111B Local Resource. 50 m-radius buffer zone recommended.
123	S31° 19' 04.5" E24° 51' 50.3"	Winterhoek 118. Stream bed exposure of Katberg Fm mudrocks with baked sandstone cast of vertebrate burrow and associated, disarticulated skeletal remains – mainly limb bones - of a medium-sized tetrapod (probably therapsid). Proposed Field Rating 111B Local Resource. 50 m-radius buffer zone recommended (See Almond 2017).

Palaeontological assessment.